Manual Therapy and Cerebral Palsy: A Narrative Literature Review

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ABSTRACT

Objective: The purpose of this paper was to collect and review articles to determine the effectiveness of manual therapy for the treatment of cerebral palsy. This exploration of such a diverse topic would help to synthesize the body of evidence available to practitioners of manual therapy-based disciplines.

Methods: A systematic search was performed to identify literature related to manual therapy and cerebral palsy symptoms. For potential inclusion, articles must have been published in a peer-reviewed journal. Database access was provided by Palmer College of Chiropractic and included: Index to Chiropractic Literature, Alt Health watch**,** MEDLINE Complete, CINAHL Complete, Academic search primer, Information Science and Technology Abstracts, EBSCO host, Dynamed, and PubMed.

Results: The current level of evidence in the literature, while overall positive, is limited and inconclusive due to complications of small study sample size, mixed results across techniques, and multiple trials consisting of mainly pilot studies. The findings of this review are consistent with reviews that had evaluated portions of the investigated topic.

Conclusion: While the studies in this review outline the prospective benefits of manual therapy on visceral function and management of spasticity, the results were complicated by study limitations. Further inquiry into the effectiveness of manual therapy techniques including joint manipulation, tissue mobilization, and diaphragmatic stretching techniques should be conducted in larger studies to determine the replicability of the observed optimistic therapy effects.

Key Words: cerebral palsy, spasticity, manual therapy, manipulation, visceral function.

INTRODUCTION

The purpose of this project was to collect and review articles to determine the effectiveness of manual therapy for the treatment of cerebral palsy. The exploration of such a diverse topic would allow for practitioners of manual therapy-based disciplines to have a synthesized review to inform clinical decision making. An examination of the current published literature around the effectiveness of manual therapy as a treatment for individuals with cerebral palsy was conducted.

Cerebral palsy is a neurodevelopmental disorder involving abnormalities in muscle tone and motor function due to damaged cerebral tissue in development and is not a single disease but rather a heterogeneous clinical syndrome.[1] Cerebral palsy is the most common physical disability of childhood, occurring in 1 out of 323 children in the United States.[2] Despite nonprogressive neurological deficits, the prognosis varies depending on severity of impairment, birth weight, and socioeconomic status.[1] Due to the incurable nature of this condition the overall goal of clinical management of cerebral palsy is to improve function, participation, and mobility while reducing complaints of limitations and pain. The significance of this project is to evaluate the current literature on management of cerebral palsy through utilization of manual therapy.

The current healthcare model calls for an optimum team which includes "a primary care physician experienced in neurological rehabilitation, a psychologist, a physical therapist, an occupational therapist, a speech therapist, a social worker, and a schoolteacher" to provide high quality patient care.[3] Encompassing a wide-range of techniques, manual therapy has been defined as "physical treatments used by physiotherapists, chiropractors, osteopaths, and other practitioners" for the treatment of musculoskeletal disabilities and pain. Commonly included under this umbrella term are techniques such as "massage therapy, joint mobilization, and manipulation".[4] If a manual therapy specific treatment is shown to have a positive impact on patient outcomes, it could provide the opportunity for manual therapy to play a valuable role in the management of cerebral palsy. It would be beneficial to have a collection of current literature to examine the potential that manual therapy has in a treatment plan for cerebral palsy.

METHODS

A systematic search was performed to identify literature related to manual therapy and cerebral palsy symptoms. For potential inclusion, articles must have been published in a peer-reviewed journal. Database access was provided by Palmer College of Chiropractic and utilized the databases listed in **Table 1**. The search terms utilized, along with the associated MESH IDs are listed in **Table 2**. The compiled research used for this review consisted of randomized clinical trials and controlled clinical trials. An additional requirement for inclusion was the reviewed literature must include an aspect of manual therapy. The treatment effect of manual therapy techniques was evaluated using outcome measures quantifying quality of life changes such as the Gross Motor Function Measures (66 item or 88 item),[5-8] Timed up and Go (TUG),[9] Peabody Gross Motor scale,[10] and the Visual Analogue Scale.[6,11-13] Clinical evaluations such as Center of Pressure (COP) displacement,[9] Spirometry,[14,15] musculoskeletal ultrasound, [14] and the "Neuroflexor"[16] spasticity measuring device were used as objective measures in clinical evaluation. These measures have been shown to be valid and reliable for evaluation of functional performance in individuals with cerebral palsy. Articles used were selected based on the use of manual therapy specifically for cerebral palsy with the intention to decrease symptoms or improve functional ability. All additional treatment interventions to manual therapy were noted to ensure that outcomes were reflective of the effects of manual therapy. Additionally, supplemental treatment interventions or medications the patient was taking were recorded. This review did not require human subject considerations as it consisted only of a search of the current body of literature. The inclusion and exclusion criteria below were used to determine what studies were included in this review.

Table 1

(Databases searched 1980-February 2021)

- Index to Chiropractic Literature
- Alt Health watch
- MEDLINE Complete
- CINAHL Complete
- Academic search primer
- Information Science and Technology Abstracts
- EBSCO host
- Dynamed
- PubMed
- Hand Searching for articles

Table 2

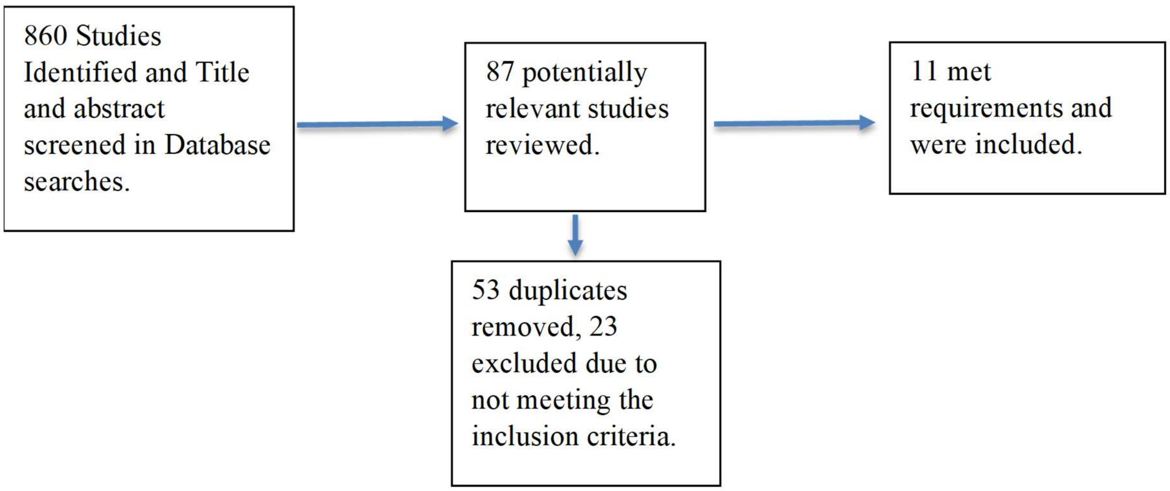
- Cerebral Palsy: MeSH Unique ID: D002547
- Spinal Manipulation: MeSH Unique ID: D020393
- Manual Therapy: MeSH Unique ID: D026201
- Manipulation, chiropractic: MeSH Unique ID: D026882
- Muscle spasticity: MeSH Unique ID: D009128
- Quality of life: MeSH Unique ID: D011788

Inclusion Criteria:

- The study must be peer reviewed
- Treatment must include manual therapy as a primary treatment
- Treatment effect must be examined with an applicable outcome assessment tool
- Study must be a randomized controlled trial or clinical trial

Exclusion Criteria:
- Unrelated to cerebral palsy
- No manual therapy component
- Incomplete study

Figure 1: Inclusion/Exclusion Flow Chart



RESULTS

The literature search identified 860 articles and 87 potentially relevant studies were reviewed. After evaluation, 11 articles met the requirements for inclusion and were included in the final analysis. The included studies are summarized in **Table 4** below.

Table 4: Evidence Table

Reference	Sample	Test	Study Design	Design/Treatment intervention	Results
Bennet et al. 2021	Fifty-three children with spastic CP were randomly assigned to experimental (n = 27) and control (n = 26) groups.	The outcome variables were diaphragmatic mobility assesed via ultrasound, pulmonary function via spirometry and chest wall expansion.	Randomized Control Trial	The experimental group received Manual diaphragmatic stretching technique (MDST) on non-consecutive days, three days per week for six weeks alongside standard physiotherapy (SDPT), while the control group received only SDPT.	MDST significantly improved diaphragmatic mobility on both sides of the body, with a between-group difference of 0.97 cm (95% CI 0.55-1.39 cm, p < 0.001) for the right side and 0.82 cm (95% CI 0.35-1.29 cm, p = 0.001) for the left side. MDST significantly improved chest wall expansion at the xiphoid process and umbilical levels, with between-group differences of 0.57 cm (95% CI 0.12-1.20 cm, p = 0.013) and 0.87 cm (95% CI 0.31-1.43 cm, p = 0.003), respectively. There was no significant difference in pulmonary function testing between the groups. However, there was a statistically significant increase in FVC% predicted after treatment in the experimental group (M = 86.37%, SD = 26.22%), when compared to pre-treatment (M =81.81%, SD = 24.56%, t(26) = 2.112, p = 0.045). There was also a significant decrease in FEV1/FVC ratio among the control group after treatment (M = 103.77%, SD = 11.50%), when compared to pre treatment (M = 106.81%, SD = 11.00%, t(25) = 2.262, p = 0.033).
Hansen et al. 2012	8 children with spastic cerebral palsy of mild to moderate severity (Gross Motor Function Classification Measure levels II, III, and IV), aged 2 to 7 years old	The primary outcome measure was the Gross Motor Function Measure-66	Randomized crossover design	Each child was scheduled for 10 weekly 60- to 90-minute sessions of the intervention (myofascial structural integration) and 10 weekly sessions of a control intervention (play). Half of the children underwent play followed by myofascial structural integration and the other half in the reverse order.	Results showed that 6 of 8 children had improvement in their Gross Motor Function Measure score during myofascial structural integration treatment. The mean change on the Gross Motor Function Measure score after treatment for the 7 (of 8) that completed the test was a positive 4.49; mean change after play was positive 1.52. For 2 children younger than age 5 years (Gross Motor Function Classification Measure level II), the average change on the Gross Motor Function Measure score after approximately 3 months of treatment was a positive 7.4. This degree of change exceeds the expected average change on the Gross Motor Function Measure over 12 months for this age (anticipated mean change of +7.00, +3.19, and +3.35 for Gross Motor Function Classification Measure levels II, III, and IV, respectively). For the 5 children older than age 5 years, the mean change on the Gross Motor Function Measure score after treatment was a positive 3.2 over 3 months; this change also exceeds the expected average change on the Gross Motor Function Measure over 12 months for that age (near 0 for all Gross Motor Function Classification Measure levels). It was found that 3 of the children showed improvement only during treatment, and 3 children showed improvement in scores after treatment and after the control condition. Consistent improvements in ankle range of motion (ROM) across the group were not found. However, 3 children showed considerable improvements in ankle dorsiflexion after myofascial structural integration treatment. All the children (including 2 children who did not show improvement in Gross Motor Function Measure score) experienced improvements to their health and well-being after myofascial structural integration treatment that were not reflected in the measured outcomes but were reported by parents at the exit interview. Parents reported positive changes in their children's appetite (n =5), bowel function (n= 1), speech (n= 2), drooling (n= 3), and mood and maturity (n= 4). Out of 8 parents, 7 also reported an increase in height and/or weight during the treatment in children previously below the normal growth curve.
Kachmar et al. 2018	8 participants with spastic CP (7-18 years) without contractures or hyperkinetic syndrome	Wrist muscle spasticity was measured quantitatively with NeuroFlexor (Aggero MedTech AB, Solna, Sweden), a device assessing resistance to passive movements of different velocities. Between-group difference was calculated using the Mann-Whitney U test. Manual dexterity was evaluated by the Box and Block test.	Randomized Control Trial	The experimental group underwent SM to the cervical, thoracic, and lumbar spine, and the control group received sham SM. A second evaluation was performed 5 minutes postintervention.	In the experimental group, a statistically significant decrease in the neural componet of muscle spasticity was measured. Spasticity was reduced by 2.18 N from a median 5.53 N with interquartile range of 8.66 to a median 3.35 newton with interquartile range of 7.19; the difference was statistically significant (P = .002). In the control group, reduction in spasticity was negligible. The between-group difference in change of muscle spasticity was statistically significant (P = .034). Improvement of manual dexterity was not statistically significant (P = .28).
Youn et al. 2020	We recruited 32 children (spastic diplegia) diagnosed with CP and categorized them in two groups: the ankle joint mobilization (n = 16) group and sham joint mobilization (n = 16) group	passive ROM in ankle dorsiflexion in the sitting and supine position, center of pressure (COP) displacements (sway length, area) with eyes open (EO) and closed (EC), and a gait function test (timed up and go test (TUG) and 10-m walk test)	single blind, randomized controlled trial with two groups	Following a six-week ankle joint mobilization, the authors examined measures such as passive ROM in ankle dorsiflexion in the sitting and supine position, center of pressure (COP) displacements (sway length, area) with eyes open (EO) and closed (EC), and a gait function test (timed up and go test (TUG) and 10-m walk test).	The dorsiflexion ROM, TUG, and 10-m walk test significantly increased in the mobilization group compared to the control group. Ankle joint mobilization can be regarded as a promising method to increase dorsiflexion and improve gait in Cerebral Palsy-suffering children.

Rutka et al. 2021	Influence of Chest and Diaphragm Manual Therapy on the Spirometry Parameters in Patients with Cerebral Palsy: A Pilot Study	Spirometry test	Randomized Control Trial	The spirometry test was performed six times in the following order: (1) at baseline, (2) after the first and after the third simulated sham therapy, (3) two-week break (no spirometry measurements), (4) before the actual therapy, and (4) after the first and third actual STM therapy sessions.	No difference was found with FVC between the first and third sham manual therapies. After the first actual therapy, FVC increased by 16% compared to the baseline measurement (p < 0.001). After the third actual therapy, FVC increased by 19% from baseline (p < 0.001). FEV1 after the first actual therapy increased on average by 0.18 L (95% CI 0.17–0.21, p = 0.04) and after the third actual therapy by 0.24 L (95% CI 0.18–0.31, p = 0:005) as compared to the baseline results. An increase in FEV1 by 0.18 L is statistically but not clinically significant. After the third therapy, both clinical and statistical increases in FEV1 were observed. No difference was found with regard to FEV1 between the first and third sham therapies. After the first actual therapy, FEV1 increased by 16% compared to baseline (p = 0.05). After the third actual therapy, FVC increased by 20% compared to baseline measurement ((p = 0.003). No statistical differences were found for PEF or FEV1/FVC measurements.
Tarsuslu et al. 2009	13 children with cerebral palsy diagnosed as having chronic constipation by a gastroenterologist.	Gross Motor Functional Classification System, Functional Independence Measure for Children, and Modified Ashworth Scale were used to determine the level of disability, functional independence, and muscle tonus, respectively. In addition, Constipation Assessment Scale was administered to the subjects to determine the severity of constipation. The satisfaction from the treatment was measured using a Visual Analogue Scale at 3 and 6 months.	Randomized Control Trial	The subjects were separated into 2 groups. Group 1 was treated with osteopathic methods and group 2 underwent both intervention with medication and exactly the same osteopathic treatments of group 1. Osteopathic treatments included fascial release, iliopsoas muscle release, sphincter release, and bowel mobilizations.	Most of the children included in this study were determined as level IV or V according to Gross Motor Functional Classification System. The satisfaction of the subjects or the families with the treatments was not different when the groups were compared (P > .05). Constipation Assessment Scale scores decreased significantly in both groups (P < .05). Pretreatment (initial evaluation) and posttreatment (follow-ups at 3 and 6 months) results revealed no difference between the groups in either aspects (P > .05). However, both groups showed significant improvements compared with baseline evaluations (P < .05). Osteopathic methods alone were as effective as osteopathic methods combined with medication intervention. The results of this study suggest that osteopathic methods may be helpful as an alternative treatment in constipation.
Wyatt et al. 2011	142 children from Greater London and the South West of England, aged 5-12 years with cerebral palsy.	Blind assessment of motor function by physiotherapists using the Gross Motor Function Measure-66 (GMFM-66) and quality of life using the Child Health Questionnaire (CHQ) PF50 at 6 months.	Randomized Control Trial	Children randomised to the intervention arm were invited to have six cranial osteopathy sessions: three in the fi rst 10 weeks and the remaining sessions within the 6-month study period. All practitioners were experienced, qualified osteopaths, registered to practice with the General Osteopathic Council. No attempt was made to constrain the form of osteopathic therapy given. Each child was assigned an osteopath who planned the course of therapy based on their assessment of the child's individual needs. A total of 37 osteopaths provided treatment. In order to provide a partial attention control, parents of children allocated to the 6-month waiting list were invited to take part in two semistructured interviews to ascertain their views of services for their children and their decision mak ing about CAM therapies. After children in the control group had completed the final assessment at 6 months, they were given a voucher entitling them to six prepaid sessions of cranial osteopathy. Parents were asked that their child not begin any new CAM therapies while in the trial and to continue with their usual management as recommended by the health and education professionals working with the family. To detect a clinically significant difference between groups of 0.6 SDs in the primary outcome measures, the GMFM-66 and the CHQ PF50, with 90% power and at the 5% signifi - cance level, 60 children were needed in each group (120 children in total). The authors planned to recruit a total of 150 children to allow for a possible 20% loss to follow-up. Parents and osteopaths completed forms after each treatment session to monitor compliance.	Compared with children in the control group, children in the osteopathy group demonstrated no statistically significant differences in GMFM-66 (mean difference 4.9, 95% CI -4.4 to 14.1), CHQ Physical Summary Score (mean difference 2.2, 95% CI -3.5 to 8.0) or CHQ Psychological Summary Score (mean difference 3.4, 95% CI -0.8 to 7.7). There were no significant differences between groups with respect to pain; sleep (either 'time asleep' or 'time to sleep'); or main carer's quality of life. Compared with children in the control group, carers of children receiving cranial osteopathy were nearly twice as likely to report that their child's global health had 'improved' at 6 months rather than 'decreased' or 'remained the same' (38% vs 18%; odds ratio 2.8, 95% CI 1.1 to 6.9). This trial found no statistically significant evidence that cranial osteopathy leads to sustained improvement in motor function, pain, sleep or quality of life in children aged 5-12 years with cerebral palsy nor in quality of life of their carers.
Duncan et al., 2008	55 children, 38 (69%) were boys. All children were between the ages of 20 months and 12 years. Only 3 children (5%) were younger than 24 months. Forty-three children (78%) were aged 4 years or older.	Outcome measures included standard instruments used in the evaluation of children with cerebral palsy. Less traditional measures were also used, including spinal evaluations by an independent blind osteopathic physician and visual analog scale assessments by an independent osteopathic physician and the parents or guardians. A total of 11 outcome variables were analyzed.	Randomized Control trial	Fifty-five patients were included in the study. Individual analyses of the 11 outcome variables revealed statistically significant improvement in two mobility measures for patients who received OMT--the total score of Gross Motor Function Measurement and the mobility domain of Functional Independence Measure for Children (P<.05).	No statistically significant improvements were seen among patients in the acupuncture treatment arm. A series of treatments using osteopathy in the cranial field, myofascial release, or both improved motor function in children with moderate to severe spastic cerebral palsy. These results can be used to guide future research into the effectiveness of OMT or acupuncture in treating children with spastic cerebral palsy.
Silva et al.,2012	28 children under age 4 with developmental delay and motor tone abnormalities. Fourteen children had high motor tone as a result of cerebral palsy (CP), and 14 children had low motor tone as a result of Down syndrome.	Peabody Gross Motor Scale (PGMS) Object Manipulation scores	Randomized controlled trial	Both groups received a qigong massage intervention delivered by trained staff and parents for 5 mo. The trainer version is given weekly and designed to advance the progress of the child from week to week. The parent version is given daily and designed to maintain and support progress and strengthen the child on a daily basis. Group A (n = 14) received 5 mo of treatment. Pretesting and posttesting of sensory abnormalities and gross motor skills was carried out for both Group A and Group B. A single experienced evaluator who was not blind to group conducted the motor evaluations. At the end of 5 mo, Group B (n = 11) began receiving treat ment, and another set of posttreatment data was col lected. A final data set to evaluate the maintenance effect for both groups was collected 10 mo after the start of treatment (n = 21)	Multivariate analysis and post hoc analysis of variance showed large effect-size improvements in Peabody Gross Motor Scale (PGMS) Object Manipulation scores (p < .01) and large effect-size improvements in overall PGMS scores (p < .04) in treatment versus control groups after 5 mo intervention. Follow-up evaluation 10 mo from the start indicated continued improvement. Sensory responses showed no treatment effect.
Mahmood et al., 2020	37 subjects in the control with a mean age of 6.81+/- 2.31. 38 in the intervention group with a mean age of 7.05+/- 2.47.	Modified Ashworth scale	Randomized controlled trial	Both groups received routine physical therapy in 30-minutesboth groups received routine physical therapy in 30-minute sessions once daily, five times a week for three months. However, the intervention group also received traditional massage in 30-minute sessions additionally before the start of exercises. Routine physical therapy provided to both the groups comprised stretching exercises, strengthening exercises and positioning. Each spastic muscle was stretched up to the level of mild discomfort where it was held for 20 seconds and the procedure was repeated five times.	Reduction in MAS grades were statistically significant in the right upper limb at the 6th week (p<0.05) , and in the right lower limb after the 12th week (p<0.05) in the intervention group. There was statistically significant difference from the baseline to the 6th and 12th week readings in both groups.
Rasool et al., 2017	60 children, 30(50%) in each group. The control group consisted of 14(46.7%) males and 16(53.3%) females compared to 16(53.3%) males and 14(46.7%) females in the experimental group (p=0.72). The overall mean age was 6.03±1.73 years.	Modified Ashworth scale	Double-blind randomized controlled trial	Both groups were given routine physiotherapy treatment which consisted of applying hot pack for 15 minutes and Bobath treatment (reflex inhibitory postures) followed by stretching the Achilles tendon (10 repetitions with at least 8 seconds hold); however, the intervention group was additionally provided with cross-friction massage on both the legs at soleus and gastrocnemius along Achilles tendon. Treatment session for both groups lasted for 30 minutes with each treatment session for 5 times a week for 6 weeks. At the end of each session, patients were assessed for improvement by an assessor blinded to the treatment.	In terms of mean MAS of controls and cases, there was no significant difference between the groups (3.87±1.19 vs 3.80±0.86) at the beginning of the study (p=0.86) and also after 6 weeks (3.73±1.22 vs 2.87±0.74) (p=0.26). However, comparative analysis within the groups showed significant improvement in the intervention group after 6 weeks (p<0.001). There was no significant difference observed between the groups with respect to functional level at the beginning (7.20±1.70 vs 6.80±2.04) and after 6 weeks (7.27±1.67 vs 6.87±1.92) of the study (p=0.56 and p=0.55, respectively)

DISCUSSION

Improved Visceral Function

Research found regarding the effect of manual therapy on patient outcomes in individuals with cerebral palsy, was included in this review regardless of positive or negative outcomes. While most of the research evaluated the effect of manual therapy techniques on spasticity and motor function, three studies evaluated the use of manual therapy as treatment of visceral limitations such as constipation and depressed pulmonary function. Bennet et al utilized manual diaphragmatic stretching technique (MDST) in children with cerebral palsy. This technique was hypothesized to stretch diaphragmatic muscles and improve chest wall expansion while also potentially activating the muscle spindle and Golgi tendon organ of the diaphragm, thus improving its contraction ability. In this study, the intervention group received 18 treatments of MDST and standard physiotherapy while the control group received only standard physiotherapy. Physiotherapy consisted of mat activities, stretching exercises, balance training, range of motion exercises, and neuro-developmental training for 40 minutes per day, three days per week, for six weeks. Results showed a clinically significant increase in diaphragmatic mobility on both sides, as well as lower chest and abdominal expansions in the MDST group, when compared with the control group. Despite the changes to mobility, no clinically significant difference in pulmonary function test variables between groups were found. However, weakness of the diaphragm can lead to recurrent pneumonia and respiratory distress, two of the most common causes of mortality in children with cerebral palsy. Therefore, the authors concluded any improvement in the motion of the diaphragm may consequently lead to a reduction in respiratory complications and improvements to these other organ systems.[14] The limitations of this study were outlined by the authors. For example, most study participants were found to have spastic diplegia, with no GMFCS level V. This specificity in tested subjects makes it difficult to extrapolate the same treatment benefits recorded in the study to different individuals.

A second study evaluated the effect of manual diaphragmatic release technique. Rutka et al evaluated the effect manual therapy plays on chest and diaphragm function as measured by spirometry in patients with cerebral palsy. In the therapeutic intervention group, a clinically significant improvement in forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) was noted after the first session of therapy. The improvements of both parameters were on average 15% to 16% after the first therapeutic session. Further treatment brought a further increase in the average values of these parameters, but they were insignificant in relation to the results obtained after the first therapeutic session in the experimental group. The control group who received sham therapy had no differences in the stated parameters. Because the sham group had no treatment effect, the author concluded that the measurable effect after manual therapy was not related to learning or the placebo effect.[15]

A third study which evaluated changes in visceral function was a pilot study that evaluated the effect of osteopathic treatment on children with cerebral palsy who were suffering from constipation. Tarsuslu et al found constipation is one of the most frequent problems in children with cerebral palsy because of several reasons such as insufficient nutrition, malnutrition, increased muscle tone, decreased defecation, and immobilization. The osteopathic treatment in the study included fascial release, iliopsoas muscle release, sphincter release, and bowel mobilization which were conducted in the given order during a 30-minute session. The intervention group was treated with osteopathic methods and included seven participants. The second group included six participants and underwent both medication and the same osteopathic treatments as group one. Although there were important improvements of symptoms in both groups, there was no difference between groups. The authors concluded this may indicate that the drug regimen had no additional beneficial effects on constipation whereas osteopathic methods alone might cause these improvements.[17]

Spasticity/mobility Improvements

The most measured impact of manual therapy on cerebral palsy was regarding changes in spasticity. Eight studies evaluated the impact of various forms of manual therapy from utilization of joint or osteopathic manipulation to various massage techniques.

First, Youn et al found a clinically significant increase in all ankle range of motion in the experimental group after joint mobilization compared to the control group which received sham therapy. Spasticity exacerbates joint contracture and muscle weakness as well as contributes to changes in muscle contractile properties. Ankle joint mobilization can be applied to reduce the spasticity of the soleus muscles, restore ankle joint flexibility, and causes articular reflexogenic effects consequently increasing dorsiflexion muscle strength. Furthermore, ankle joint mobilization may also improve balance as the authors found that it can reduce center of position displacement by improving sensory motor function and arthrokinematic restrictions. The study concluded ankle joint mobilization improved ankle range of motion and gate in cerebral palsy. However, the beneficial effect on standing balance was not confirmed.[9] The largest limitation of this study was that it failed to compare the treatment intervention to current treatment methods of patients with cerebral palsy. The authors also failed to identify adverse effects, if any occurred, of the evaluated therapy. For these reasons, the benefit of implementation in the clinical setting cannot be fully determined.

Next, three studies evaluated the treatment effect of osteopathic manipulation for management of spasticity. First, Duncan et al evaluated gross motor function changes in children following osteopathic manipulation. The authors concluded that there was statistically significant improvement from baseline Gross Motor Function Classification System scores in the osteopathic manipulation treatment group. No clinically significant changes were found in the acupuncture groups nor in the waiting list groups.[11] One limitation to this study was the failure to provide confidence intervals or P-values to support evaluation of treatment effectiveness. Additionally, it should be noted that this study was a pilot study and may serve as foundation for further research trails to be conducted.

A second study evaluated the impact of manipulation on spasticity. Kachmar et al assessed spasticity quantitatively with a Neuroflexor device by measuring the resistance to passive movement of the wrist, performed with different velocities by a computer-controlled step motor. Wrist muscle spasticity was measured quantitatively as a neural component of the muscle tone. Spinal manipulation was carried out in the thoracic, lumbar, and cervical regions. Statistically significant reduction of neural component after spinal manipulation was noted in the experimental group values dropped from the median 5.53 N to 3.35 N. In the control group, there was only a slight reduction of values from the median 6.83 N to 5.7N. Comparison between the groups revealed statistically significant difference in spasticity reduction (P=.034). The second outcome measure in the study was the study of hand dexterity measured by means of the box and block test. There was a statistically significant difference between baseline and post intervention assessment measured in both groups. In the experimental group, the pre-and post-difference was a positive 4.1 blocks per second (95% confidence interval = 5.52-2.68). In the control group, the pre-and post-difference was a positive 3.01 blocks (95% confidence interval = 4.41-1.69). While the experimental group showed a more substantial improvement, the difference between groups was not statistically significant (P= .28). The contribution of this study is that it corroborates the hypothesis that spinal manipulation may decrease muscle spasticity temporarily in participants with disordered muscle tone regulation, specifically children with cerebral palsy. Despite these positive findings, the limitations of this study were outlined extensively by the authors. The short-term design, the potential that participants in the control group may have suspected sham therapy, and the preliminary nature of findings of decreased spasticity associated with spinal manipulation were listed as considerations by the authors.[16]

A study on the potential effectiveness of Cranial Osteopathic Therapy was conducted by Wyatt et al. This study attempted to evaluate the potential improvement that this therapeutic approach may provide in the health or quality of life of children with cerebral palsy. The authors found little evidence that cranial osteopathic therapy had a sustained improvement in the health or quality of life of children aged 5 to 12 years with cerebral palsy. At six months, neither the independent assessment of motor function (GMFM-66), nor caregiver quality of life, sleep, or pain, suggested any statistically significant difference between children who had a course of cranial osteopathic treatment and those assigned to a waiting list.[18]

Myofascial Structural Integration was examined regarding the impact that it may have on gross motor function of pediatric cerebral palsy patients. In this crossover study, each child underwent 10 weekly 60-to-90-minute sessions of myofascial structural integration, in addition to 10 weekly sessions of play, which was the control intervention of the study. The advantages of this approach, as suggested by the authors, are the fact that it targets changes in the muscle and fascial tissue directly, is a noninvasive therapy, and does not interfere with the developing movement patterns of the individual. The authors found improvement in gross motor function measure scores in six children after myofascial structural integration treatment. While it was not observed that there were consistent improvements in ankle range of motion across the group, three children showed considerable improvements in ankle dorsiflexion after myofascial structural integration treatment. While the largest limitation to these findings is the small sample size of study participants, the authors concluded this preliminary study indicates that using myofascial structural integration as a specific, complementary technique to loosen and realign muscles and joints could facilitate improved motor function in young children with spastic cerebral palsy.[8]

In their study, Mahmood et al, studied the effects of traditional massage on spasticity of children with cerebral palsy. Their determination was that traditional massage, when coupled with routine physical therapy was found to have a statistically significant effect on the reduction of spasticity when compared to routine physical therapy alone. While the right-side changes were both clinically and statistically significant the left-side did not meet either of these benchmarks.[12]

Deep friction massage was investigated by Rasool et al. In their investigation, they evaluated the effect of this therapeutic approach on both spasticity and functional ability. The study described a statistically significant reduction in spasticity after six weeks, five sessions a week, of deep friction massage within the experimental group. However, between the two groups, spasticity reduction was not significant ($P = .26$). Moreover, there was no significant improvement observed in the functional level of study subjects on both within and between the group analysis.[13]

A third study evaluated the effect of massage techniques on children with cerebral palsy and down syndrome. Silva et al evaluated qigong massage techniques in the treatment group of the study. The children with cerebral palsy who received the treatment intervention experienced positive, statistically significant improvements in all three motor domains including stationary body control, locomotion/movement, and object manipulation. Children in the control group experienced minimal, non-statistically significant changes. While there were large and significant overall treatment effects in motor development (p=.039), the overall results for the sensory impairment indicated no treatment effect (p=.265). Despite the positive findings of massage intervention in this study, the authors outlined limitations that should be considered. Limitations are consistent with those of a small pilot study, including a small sample size, short period of intervention, and the need for a wider battery of outcome measures to be administered by blinded examiners.[10]

The current level of evidence in the literature, while overall positive, is limited and inconclusive due to complications of small study sample size, mixed results across techniques, and multiple trials consisting of mainly pilot studies. The findings of this review are consistent with reviews that had evaluated portions of the investigated topic. For example, Pin et al conducted a systematic review evaluating the effectiveness of passive stretching on children with cerebral palsy. The authors found that the evidence to support the effectiveness of passive stretching in children with spastic cerebral palsy remains weak. It was concluded there is some evidence favoring passive stretching to increase range of motion in children with cerebral palsy, although the effect size remains small. Additionally, there is evidence indicating that passive stretching may reduce spasticity in children with cerebral palsy, but the effect size and clinical merit remains limited. Lastly, there is some evidence to indicate that sustained stretching is preferable to manual stretching in improving range of motion and reducing spasticity in targeted joints and muscles.[19]

CONCLUSION

The prevalence of cerebral palsy has remained steady at 2.11 per 1000 live births despite increased survival of at-risk preterm infants.[20] The consistency of the prevalence of cerebral palsy warrants additional investigation into proper management and treatment options. While the studies in this review outline the prospective benefits of manual therapy on visceral function and management of spasticity, the results were complicated by study limitations. Further inquiry into the effectiveness of manual therapy techniques including joint manipulation, tissue mobilization, and diaphragmatic stretching techniques should be conducted in larger studies to determine the replicability of the observed optimistic therapy effects. Once manual therapy has been found to be effective, further studies on frequency would also be beneficial. In a similar vein, a recent study by Ryu and Suh examined the optimal frequency of physical therapy in young children with cerebral palsy.[21] The "current treatment for people with cerebral palsy involves substantial expense. The size, nature and distribution of the economic burden emphasizes the importance of finding effective strategies to reduce the risk and severity of cerebral palsy".[22] After treatment effectiveness and optimal frequency has been determined, clinical application of manual therapy can be compared in both effectiveness and cost-benefit ratio to current management techniques.

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