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The role of osteopathic manipulative medicine in cerebral palsy: bridging treatment gaps and enhancing care

<https://doi.org/10.1515/jom-2025-0055>

Received March 18, 2025; accepted September 25, 2025;

published online November 10, 2025

Abstract: Osteopathic manipulative medicine (OMM) is a hands-on approach utilized by physicians to diagnose, treat, and prevent various conditions through the application of muscle manipulation techniques. It has been applied in managing chronic musculoskeletal (MSK) pain, headaches, migraines, Parkinsonian gait, and psychological conditions such as stress, anxiety, and depression. In our narrative review, we aim to integrate both direct clinical studies of OMM in cerebral palsy (CP) and supportive literature on mechanisms and related conditions. A comprehensive literature search was conducted utilizing PubMed and Google Scholar to identify relevant studies on OMM in CP management. Search strategies were intentionally broad to capture mechanistic, supportive, and clinical evidence. Representative terms included “osteopathic manipulative medicine and cerebral palsy,” “osteopathic treatment and neurological disorders,” and “manual therapy and cerebral palsy.” Additionally, reference lists of relevant articles were manually reviewed to identify additional studies. Overall, we found that integrating OMM into CP management may offer a noninvasive approach to improving MSK function and neuromuscular control while alleviating the emotional and physical challenges, as well as increasing movement to reduce joint contractures associated with the condition. OMM techniques may also help reduce stress, anxiety, and constipation, which are prevalent among CP patients due to the psychological and physiological burdens of the disorder.

OMM’s holistic approach has the potential to enhance outcomes for individuals with CP by addressing their multifaceted needs. While further research and advocacy are necessary to fully integrate OMM into mainstream CP management, existing evidence suggests that OMM may improve patient outcomes and quality of life. However, the current evidence has remained somewhat limited.

Keywords: cerebral palsy; motor function; neurology; neurorehabilitation; osteopathic manipulative medicine (OMM); spasticity management

Cerebral palsy (CP) is a neurodevelopmental disorder that affects movement, muscle tone, and motor skills, often leading to lifelong functional impairments [1]. CP arises from various prenatal, perinatal, and postnatal factors and manifests as musculoskeletal (MSK) challenges such as spasticity, muscle stiffness, and impaired coordination, along with visceral dysfunctions like gastrointestinal (GI) and bladder issues [2]. Understanding the pathological development of CP has posed two main associations: white matter injury in premature infants due to enhanced vulnerability of white matter between 24 and 34 weeks of gestation, or gray matter lesions of the basal ganglia in full-term neonates [3]. Disruption of these areas, due to ischemia or destructive injuries, can lead to corticospinal tract lesions, leading to the development of motor disorders such as CP [3]. These areas serve as the final common pathways for motor neurons in the brainstem and spinal cord, integrating inputs from nearly all cerebellar efferent as well as the basal ganglia. The cerebellum and basal ganglia are also responsible for determining the final passive muscle tone in CP [4]. While there is currently no cure for CP, management strategies, such as physical therapy, pharmacologic interventions, and surgical procedures, are available and can be utilized with the aim of mitigating symptoms and improving quality of life [2]. Additionally, although CP often develops because of prenatal or perinatal factors, it can also be acquired from postnatal brain injuries [1].

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Osteopathic manipulative medicine (OMM) has gained attention as a complementary therapy for CP-related symptoms. Techniques such as muscle stretching, gentle pressure, and joint manipulation have been shown to reduce muscle stiffness, alleviate stress, and enhance mobility in neuromuscular disorders [5, 6]. Given the chronic nature of CP and its associated psychosocial burden, OMM offers a holistic approach that addresses both physical and psychological aspects of care [7]. Rooted in the principle that structure and function are interdependent, OMM targets biomechanical dysfunctions through hands-on techniques [6], which emphasize individualized, patient-centered care, aligning with osteopathic philosophy [5]. While research on OMM's effectiveness in CP remains limited, growing interest in osteopathic approaches highlights its potential role in symptom management [8].

This narrative review synthesizes current evidence on OMM's role in CP management, with a focus on its application within the five models of osteopathic approach: behavioral, biomechanical, neurologic, metabolic, and respiratory-circulatory [6]. By exploring these models, this review aims to establish a foundation for future research into alternative therapeutic options for individuals with CP.

Methods

Study protocol and sources

This review was conducted as a narrative synthesis of the literature to evaluate the effectiveness of OMM in managing symptoms and improving quality of life in patients with CP. The objective was to summarize clinical evidence, highlight mechanisms of action, and identify evidence gaps, rather than to perform a fully systematic review. A comprehensive literature search was conducted utilizing PubMed and Google Scholar to identify relevant studies on OMM in CP management. Search strategies were intentionally broad to capture mechanistic, supportive, and clinical evidence. Representative terms included “osteopathic manipulative medicine and cerebral palsy,” “osteopathic treatment and neurological disorders,” and “manual therapy and cerebral palsy.” Additionally, reference lists of relevant articles were manually reviewed to identify additional studies.

Inclusion and exclusion criteria

The inclusion criteria required that studies be published between January 2005 and March 2025. Articles published between January 2015 and March 2025 were prioritized for full-text review to ensure that the review reflected the most

current and relevant literature. Articles had to be written in English and either directly focus on individuals with CP receiving OMM interventions or provide supportive mechanistic/contextual evidence relevant to CP management. Studies were excluded if they did not incorporate OMM as an intervention, focused on non-OMM manipulative therapies such as chiropractic or standard physical therapy alone, or were opinion pieces, editorials, preprints, or unpublished reports. Nonhuman studies were excluded.

Study design and data collection

The included studies consisted of randomized controlled trials (RCTs), cohort studies, case-control studies, systematic reviews, and meta-analyses that assessed OMM's role in CP management. In addition, supportive and mechanistic studies were included to provide context and insight into potential pathways through which OMM may influence CP outcomes. Articles were screened for relevance to OMM and CP by two authors, with consensus reached through discussion. Eligible articles then underwent a full-text review, with disagreements resolved through consensus or by consulting a third reviewer. For each included study, data extraction involved collecting information regarding the author(s) and year of publication, study design, sample size, duration of intervention, outcome measures, and key findings. Extracted data were systematically organized into summary tables for analysis, ensuring a structured comparison of findings across studies.

Results

Osteopathic manipulative medicine and its five-model biomechanics

OMM is a core component of osteopathic care, emphasizing the interrelationship between structure and function to support self-regulation and healing [6]. It employs hands-on techniques to diagnose and treat somatic dysfunctions, which are identified through Tissue texture abnormalities, Asymmetry, Restriction of motion, and Tenderness (TART) criteria [7]. In CP patients, OMM primarily targets MSK dysfunctions like spasticity and muscle stiffness rather than pain relief.

OMM techniques – including muscle energy (ME), myofascial release (MFR), articular techniques, counterstrain, balanced ligamentous tension (BLT), Still's technique, doming the diaphragm, lymphatic pump, rib raising, and cranial osteopathy – are tailored to individual patient needs [6, 9]. Although widely utilized for MSK disorders

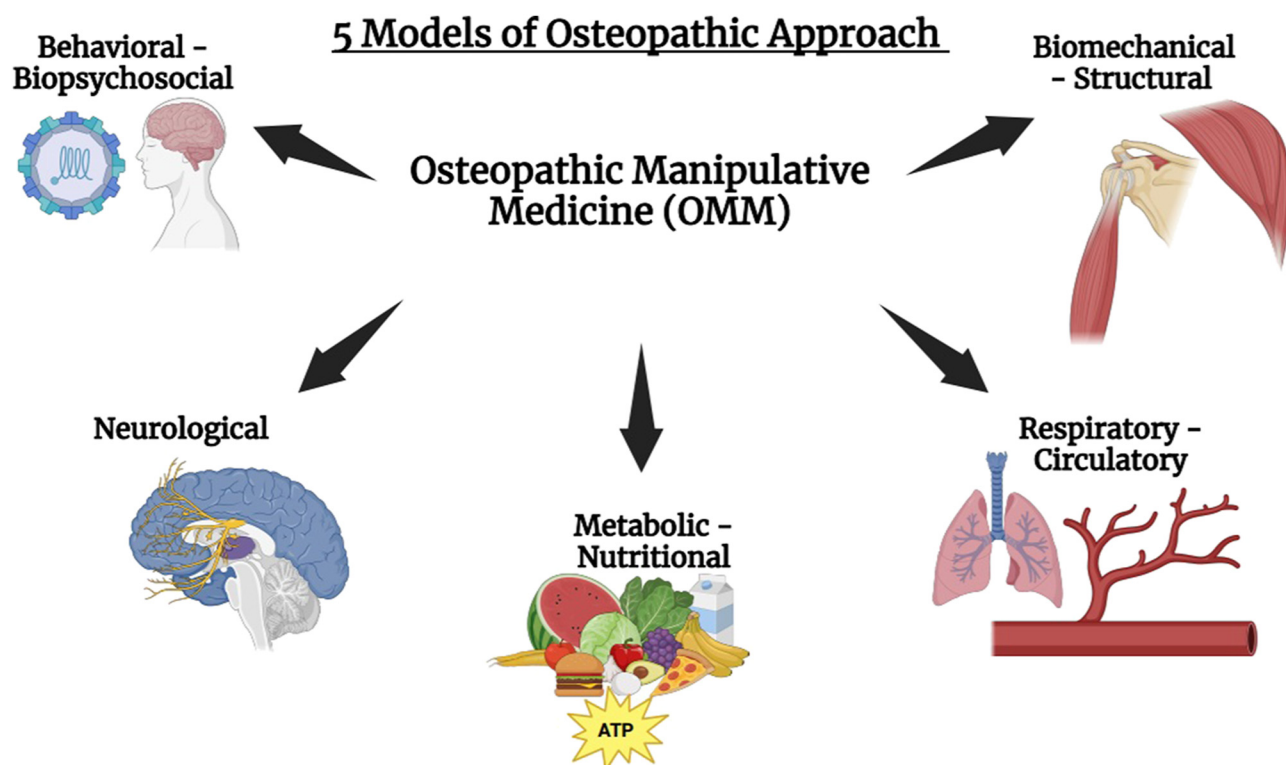


Figure 1: Diagram illustrating the five models of osteopathic approach: behavioral-biopsychosocial, neurological, metabolic-nutritional, respiratory-circulatory, and respiratory-structural.

such as nonspecific lower back pain, OMM's adaptability allows for integration into CP management [8]. For an in-depth discussion on technique applications, refer to Sef-finger et al. [7].

The five models of osteopathic medicine

As Figure 1 illustrates, the Five Models of Osteopathic Approach guides osteopathic diagnosis and treatment by addressing different physiological systems [7].

- Biomechanical-Structural Model: Targets structural abnormalities to restore function and mobility.
- Respiratory-Circulatory Model: Optimizes circulation and fluid dynamics to maintain homeostasis.
- Neurological Model: Addresses neural dysfunctions affecting CP pathology.
- Metabolic-Nutritional Model: Focuses on energy utilization and metabolic efficiency.
- Behavioral-Biopsychosocial Model: Recognizes psychosocial stressors and their impact on health.

Applying these models to CP patients enables individualized treatment strategies that address the disorder's complexities.

Cerebral palsy and its mechanisms of disease

CP is a neurodevelopmental disorder resulting from abnormal brain development or injury, affecting approximately 1 in 500 neonates and 17 million people worldwide [10, 11]. Understanding its pathophysiology is essential for improving treatment strategies. CP primarily involves damage to motor control regions of the brain, often due to fetal hypoxia and asphyxia, which trigger inflammatory cascades and further tissue damage [4, 12]. Clinically, CP presents with abnormal muscle tone, weakness, atrophy, and coordination deficits [13]. Its etiology is multifactorial, involving genetic mutations in the FBXO31 and RHOB genes, hypoxia, birth complications, and environmental factors, with many causative events occurring prenatally [14, 15].

Current treatments and therapies for cerebral palsy

Currently, there is no cure for CP; however, available treatments focus on symptom management and improving quality of life. Preventive strategies include maternal interventions such as magnesium sulfate, corticosteroids, progesterone

therapy, and aspirin for hypertension conditions during pregnancy, such as pre-eclampsia prevention [16]. Additionally, neonatal interventions, including therapeutic hypothermia, caffeine therapy, and delayed umbilical cord clamping, have shown promise in reducing CP incidence [17].

Pharmacologic treatments targeting spasticity include baclofen, diazepam, tizanidine, clonazepam, and dantrolene. For severe cases, intrathecal baclofen and botulinum toxin injections provide targeted relief [16]. Surgical options, such as selective dorsal rhizotomy (SDR) for spasticity reduction and deep brain stimulation (DBS) for dystonia, offer additional management strategies. Orthopedic surgeries, including tendon lengthening, transfers, and reconstructive procedures, have also been shown to improve mobility, posture, and joint function [18]. Rehabilitative therapies play a critical role in optimizing motor function and independence, with advancements in robot-assisted gait training further enhancing both upper and lower limb function [19].

Effects of OMM on diseases/disorders other than cerebral palsy

OMM has been applied in the treatment of CP as well as various other conditions, with varying levels of evidence supporting its effectiveness. It has been utilized to manage chronic MSK pain, headaches, migraines, Parkinsonian gait, and psychological conditions such as stress, anxiety, and depression [6]. OMM has demonstrated significant benefits in pain reduction. For example, a study on chronic neck pain found that OMM reduced pain and disability while improving sleep, fatigue, and depression scores, with the effects lasting at least 4 weeks [20]. Similarly, OMM for chronic low back pain has demonstrated pain reductions comparable to nonsteroidal anti-inflammatory drugs (NSAIDs), with both short- and long-term relief reported in multiple studies [21–23].

OMM has also been explored for headache and migraine management, with techniques such as myofascial tissue release, cranial OMM, and suboccipital inhibition leading to decreased pain intensity, improved mental well-being, and reduced medication reliance [24]. In Parkinson's disease (PD), OMM has shown promise in improving gait kinematics. A study utilizing motion analysis found that PD patients had reduced hip and knee extension, which significantly improved after a single OMM session, suggesting potential benefits for mobility [25].

OMM's impact on psychological dysfunctions has also been linked to its effects on stress and inflammation. A pilot study in first responders found that OMM reduced stress, anxiety, and depression while increasing job satisfaction [5].

Participants showed decreases in stress-related biomarkers, including interleukin 6 (IL-6), brain-derived neurotrophic factor (BDNF), IL-2, IL-17 α , and cortisol. These biomarkers are implicated in anxiety, depression, and chronic stress [26–28]. The findings highlight OMM's potential as an adjunctive therapy for pain, neurological dysfunction, and stress-related disorders, reinforcing its role in holistic healthcare.

Stress and mental health challenges that link OMM to cerebral palsy

Individuals with CP face higher risks of depression and anxiety, exacerbated by mobility limitations, social isolation, and cognitive challenges [29–31]. These factors contribute to reduced energy, appetite, and motivation, creating a cycle of poor mental and physical health [30].

OMM provides a holistic approach to addressing MSK imbalances, with studies indicating benefits in physical symptoms and mental health, including improvement of anxiety and depression [32]. Chronic stress often manifests as muscle tension and pain, while prolonged elevated cortisol and inflammatory markers further worsen health outcomes [33]. Additionally, autonomic nervous system dysregulation, seen in stress-related conditions, contributes to persistent sympathetic overactivity and an increased risk of migraines, chronic pain, and systemic inflammation [32].

OMM may help modulate autonomic function by reducing sympathetic overactivity while enhancing parasympathetic relaxation, leading to improved circulation, reduced inflammation, and neuromuscular relaxation [32]. Although direct research on OMM's mental health effects in CP is limited, existing evidence suggests that it may be a useful adjunctive therapy for managing stress-related disorders in this population. Further studies are needed to explore its long-term mental health benefits in CP patients.

Role of OMM in addressing complications associated with cerebral palsy

OMM is utilized to improve mobility, manage pain, and enhance function in CP patients. By focusing on MSK dysfunctions, OMM has been shown to have positive effects on spasticity and constipation without requiring invasive interventions such as surgery [34]. However, its efficacy in CP remains under investigation. A study of 55 children (ages 20 months to 12 years) with moderate to severe CP-related spasticity compared cranial osteopathic manipulation, acupuncture, and a control group. The acupuncture group showed no significant improvement, whereas the cranial

osteopathic group demonstrated enhanced gross motor function and mobility [35].

Cranial osteopathic techniques, such as compression of the fourth ventricle (CV-4), have been shown to optimize cerebrospinal fluid motion and autonomic flexibility [36, 37]. A study on CV-4 manipulation in CP patients found statistically significant improvements in quality-of-life measures at a 10-week follow-up, with no adverse effects [38]. Beyond cranial techniques, soft tissue manipulation and MFR are also utilized to manage CP symptoms [38]. These methods target muscle restrictions, improve mobility, and reduce discomfort [35, 39].

OMM may also aid in managing visceral dysfunctions in CP. A study comparing OMM, abdominal massage, and a control group in 29 children with CP-related constipation found that while both OMM and massage improved symptoms, OMM produced faster and more significant improvements based on constipation severity assessments [40]. These findings suggest that OMM may enhance digestive function in CP patients [41]. Currently, published studies on CP report few adverse events associated with OMM. However, there is also limited evidence showing that there is an improvement in children with CP being treated with OMM [42].

Physiological mechanisms underlying the potential benefits of OMM for cerebral palsy patients with muscular atrophy

Muscle atrophy in CP patients can reach up to 40.0 % and results from many factors, including reduced muscle mass, chronic inflammation, mitochondrial dysfunction, and oxidative stress, leading to weakness, asymmetry, and mobility loss [43–45]. The use of OMM can be beneficial in counteracting muscle atrophy through the five osteopathic models. Biomechanically, techniques like ME and MFR improve mobility, reduce mechanical strain, and minimize compensatory movements that accelerate atrophy [6]. Respiratory and circulatory techniques such as rib raising and thoracic manipulation enhance blood flow, nutrient delivery, and lymphatic drainage, reducing inflammation and promoting muscle repair [46, 47]. Neurologically, OMM stimulates proprioceptive pathways and neural function, promoting muscle activation, relaxation, and neuroplasticity [6, 48]. From a metabolic perspective, techniques like the lymphatic pump and visceral manipulation optimize nutrient exchange, energy regulation, and autonomic balance, supporting muscle growth and recovery [49]. The behavioral model highlights OMM's potential to reduce stress and enhance parasympathetic activity, improving mental well-being and rehabilitation adherence in patients

facing mobility-related frustration and anxiety [50, 51]. By enhancing circulation, reducing inflammation, restoring neural function, and promoting metabolic efficiency, OMM offers a comprehensive approach to managing muscle atrophy in CP.

Economic implications of incorporating OMM into cerebral palsy patients' healthcare management

Standard CP treatments, including botulinum toxin, muscle relaxants, SDR, and therapy, effectively manage motor impairments but impose significant financial and emotional burdens on patients and families [35, 52]. OMM offers a complementary approach that may reduce pain, enhance quality of life, and lower healthcare costs, yet insurance reimbursement remains complex [53]. Additionally, physicians must navigate extensive evaluations, coding procedures, and frequent claim denials, highlighting the need for expanded coverage and streamlined reimbursement to improve OMM accessibility [54]. Incorporating OMM into CP care reduces the use of expensive pain medications, lessening the visits to the ER and imaging studies [55, 56]. Additionally, there is a reduction in indirect costs because there is a faster recovery time, which allows for fewer missed days at work [57].

CP-related healthcare costs are substantial. The Centers for Disease Control and Prevention (CDC) estimates lifetime expenses per patient at \$921,000 [58]. Additionally, CP patients often face mobility, communication, and social challenges, increasing the risk of isolation and dependence [59, 60]. Over half of CP patients require assisted living or parental care, placing physical and emotional strain on caregivers [61, 62].

Personal assistance needs are extensive, with 20.0 % of CP patients requiring over 160 h per week for basic tasks and social engagement [63, 64]. Implementing continuity of care (COC) reduces hospitalizations and medical costs while improving mental health and patient satisfaction [65]. Integrating OMM into COC models could further optimize CP management, providing consistent, noninvasive symptom relief throughout a patient's lifespan.

Conflicting evidence and limitations in current OMM studies

Neutral findings have been reported in limited studies. For example, a 2011 study evaluated the application of cranial osteopathy in children with CP [66]. It was a British study

with a sample population of 142 children in total, 70 of whom received cranial osteopathy, and the remaining 72 formed the treatment group [66]. Then the children were observed for a follow-up period of 6 months. By the end of the follow-up period, the authors found no significant changes in the motor functions of the children who received cranial osteopathy compared to the control group, which strongly suggests that the therapy is, in fact, ineffective [66]. This and similar inconclusive results from pediatric OMM reviews emphasize that while OMM appears safe, its efficacy in CP may remain uncertain [42].

Discussion

The understanding of CP remains limited, and further research into the effects of OMM on patients with CP is both valuable and necessary. Tables 1 and 2 highlights the key findings of this review. From the 69 studies reviewed, OMM was proven to be effective in a variety of patient populations. A consistent trend showed that OMM was generally associated with better motor function, reduction in spasticity, and improved quality of life in CP patients. These studies showed positive outcomes of OMM; the evidence is based on a small sample size, subjective measuring standards, and variability in gathering data. Overall, these findings suggest a positive role of OMM as a complementary therapy. One promising area of study is pelvic obliquity, a common condition in CP patients characterized by the horizontal misalignment of the pelvis in the frontal plane [67]. If left untreated, pelvic obliquity can lead to worsening back pain, walking difficulties, and increased postural strain. Sacral OMM holds potential not only for treating pelvic obliquity but also for improving outcomes in CP patients with neuromuscular scoliosis. However, more research is required to fully understand the impact of these treatments in this context [67]. The literature highlighted in Table 2 indicates that OMM has the benefits of improving gross motor function, independence, anxiety, quality of life, heart rate, and CP-associated symptoms such as constipation. Additional benefits of OMM, highlighted by those studies, include a reduction in the length of hospital stay and complications. The studies and literature reviews were often limited by a small sample size or the inclusion of smaller studies (Table 2).

Additionally, studies have shown that a series of osteopathic treatments, including soft-tissue techniques, MFR, and cranial manipulation, can significantly improve motor function in children with CP [39]. In the literature review, three of the studies did not support the use of OMM as treatment for

Table 1: Table illustrating a summary of key findings in each section of this review.

Key findings	References
OMM and its five-model biomechanics	
To properly diagnose somatic dysfunction in patients, doctors utilize various techniques such as palpating a patient's body for tenderness, asymmetrical structures, poor range of movement, and abnormal tissue texture changes. This technique is known as TART screening.	Seffinger et al. [7]
Once a physician identifies dysfunction, many different approaches are utilized to reestablish proper bodily function. Some of these techniques include but are not limited to: ME, MFR, articular techniques, counterstrain, BLT, Still's technique, doming the diaphragm, HVLA, lymphatic pump, rib raising, and cranial manipulation.	Roberts et al. [6]
The five models of osteopathy describes the body's various systems and physiological responses allowing a proper framework for physicians to diagnose patients. The model included biomechanical-structural, respiratory-circulatory, neurological, metabolic-nutritional, and behavioral-biophysiological aspects of health.	Seffinger et al. [7]
Cerebral palsy and its mechanisms of disease	
CP is a group of disorders caused by improper development in the areas of the brain that control muscle control and movement. This condition is diagnosed in children before 2 years of age.	Marret et al. [4]
CP results in delayed developmental milestones, gait disturbances, hypertonia, hypotonia, muscle atrophy, and intention tremors.	Graham et al. [11]
	Patel et al. [13]
Current treatments and therapies for cerebral palsy	
While there is no cure for CP, there are different treatment modalities utilized to improve patient quality of life and to reduce the debilitating symptoms of this neurodegenerative disease. Preventative treatment includes magnesium sulfate and corticosteroids to reduce the risk of premature birth and low birth weight.	Novak et al. [16]
Preventative care, postnatal treatment, and nontraditional therapy are current therapies utilized for CP.	Paul et al. [17]
There are few surgical interventions that can help with patient outcomes and movement disorders of CP.	Chin et al. [18]
Effects of OMM on diseases/disorders other than cerebral palsy	
OMM is utilized in the management of chronic MSK pain, migraines, parkinsonian diseases, and psychological conditions.	Roberts et al. [6]

Table 1: (continued)

Key findings	References
OMM has shown significant improvement in pain levels.	Cholewicki et al. [20]
OMM is comparable to the effects of taking NSAIDs for acute and chronic pain.	Licciardone et al. [21]
A pilot study looking into the effects of OMT and stress levels has shown that OMM has significantly decreased psychological stress levels.	Abraham et al. [5]
Impact of OMM on the quality of life and functional abilities of individuals with cerebral palsy	
OMM has shown the potential to have positive effects on patients' quality of life with CP.	Vitrikas et al. [52]
Certain OMM techniques, such as lymphatic drainage, thoracic manipulation, and rib mobilization, have contributed to a better quality of life for individuals with CP.	Remien et al. [47]
Stress and mental health challenges that link OMM to cerebral palsy	
There has been a growing concern about the mental and physical well-being of individuals with CP.	Van et al. [29]
OMM calms the SNS while engaging the PSNS to promote mental and physical relaxation.	Sienko [32]
OMM has been shown to improve the physical and mental symptoms of CP patients, which, therefore, has improved the quality of life of those individuals.	Sienko [32]
The role of OMT in addressing complications associated with cerebral palsy	
A study in the effectiveness of OMT in CP patients showed that OMM improves total gross motor function and functional independence when compared to the control group.	Duncan et al. [35]
OMM manipulation involving the fourth cranial ventricle in children showed significant improvements in enhancing tissue fluid motion and increasing autonomic flexibility.	Jakel and von Hauenschild [38]
The MFR technique improves the body's healing process by releasing muscle restriction.	Roland et al. [39]
Physiological mechanisms underlying the potential benefits of OMM for CP patients with muscular atrophy	
CP patients experience significant muscle wasting, up to 40 % in volume and less sarcomeres, at an early age.	Handsfield et al. [45]
OMM improves muscle atrophy in CP patients by utilizing techniques such as ME and MFR, and improving biomechanics, which in turn mitigate more muscle atrophy.	Roberts et al. [6]

Table 1: (continued)

Key findings	References
OMM stimulates neural pathways via HVLA.	Roberts et al. [6]
Rib raising stimulates sympathetic chain ganglia, re-establishing autonomic balance.	Whelan et al. [48]
Cranial osteopathy and neural mobilization work to enhance nerve function, improving muscle activation function and lessening muscle atrophy.	Whelan et al. [48]
Overall, OMM addresses biomechanical, physiologic, neurologic, metabolic, and behavioral factors influencing muscular atrophy.	Fornari et al. [51]
Economic implications of incorporating OMM into the healthcare management of individuals with cerebral palsy	
Treatments of CP have led to significant economic and financial distress on patients and their families.	Duncan et al. [35]
OMT has provided alternative routes to help improve symptoms, quality of life, and financial burden for those with CP.	Snider and Jorgensen [53]
CP symptoms have made it difficult for patients to develop relationships, leading to social isolation. Patients living with CP often need personal assistance multiple times a week. Implementing continuity of care has reduced costs and enhanced the quality of life for individuals with CP.	Jespersen et al. [59] Michelsen et al. [60] Alriksson-Schmidt et al. [63] Chen et al. [65]
BLT, balanced ligamentous tension; CP, cerebral palsy; HVLA, high-velocity, low-amplitude; ME, muscle energy; MFR, myofascial release; MSK, musculoskeletal; NSAID, nonsteroidal anti-inflammatory drug; OMM, osteopathic manipulative medicine; OMT, osteopathic manipulative treatment; PSNS, parasympathetic nervous system; SNS, sympathetic nervous system; TART, tissue texture abnormalities, asymmetry, restriction of motion, and tenderness.	

CP. The state of evidence for CP treatments by Novak et al. [16] classified cranial sacral osteopathy as a red-light treatment with no differences between groups. The literature review by Dwyer et al. [41] concludes that several of the studies investigating the efficacy of manipulation techniques in CP patients require replication with larger sample sizes to serve as definitive evidence. Finally, the study by Wyatt et al. [66] found no statistically significant differences in quality of life, sleep, and pain between the group of CP patients that received cranial OMM and the group that did not.

In contrast, three studies directly supported the use of OMM as treatment for CP. The study by Duncan et al. [35] found that OMM led to statistically significant improvements in gross motor function and functional independence in CP patients. The literature review by Zurowska et al. [37] lists soft tissue, MFR, and balance ligamentous tension as OMM techniques, with clinical findings supporting their use in improving CP patients'

Table 2: Summary of key studies evaluating the outcomes of incorporating OMM into the treatment regimen.

Study	Duncan et al. [35]	Jakel and von Hauenschild, [38]	Chatip et al. [40]	Goering et al. [36]	Żurowska et al. [37]	Roland et al. [39]
Study design	Single-blind RCT, waitlist control	Systematic review	RCT	Single-blind, controlled study	Systematic review of RCTs	Narrative review of multiple studies, including RCTs and observational studies
Sample size	55 children (20 months to 12 years)	19 studies included; 3 pediatric populations	Outpatient/home-based program	Western University of Health Sciences; 2-day in-person study	Multiple international sites; RCTs from various countries	Varies across studies (eg, n=695 in one multicenter RCT)
Population	Moderate to severe spastic cerebral palsy	Various, including infants and children with neurologic impairment	29 children with CP (n=10 control, n=10 AMHP, n=9 OMT-H)	64 medical students (1st and 2nd year)	7 RCTs included, primarily small sample sizes; most<30 participants	Preterm and term infants in NICUs globally
Intervention	OMT (cranial + myofascial release), 10 sessions over 24 weeks	Craniosacral therapy (a subtype of OMT)	OMT home program vs. abdominal massage vs. control, 10 sessions over 3 weeks	Healthy medical students naive to cranial OMM	Primarily healthy adults; a few with TTH or LBP	OMT (eg, MFR, BLT, OCM, LPT, diaphragm treatment)
Comparator	Acupuncture group and wait-list control group	Varied – often standard care or sham treatment	MCAS, Rome III criteria, BSFS	One CV4 treatment delivered by trained osteopathic physicians	CV4 technique performed by osteopaths, physiotherapists, and craniosacral therapists	Standard care without OMT
Outcome measured	GMFM, WeeFIM, PEDI, parent/physician VAS, ashworth scale	Motor function, quality of life, physiologic parameters	OMT-H: significant improvement in MCAS from week 1 (p=0.007), Rome III (p=0.004), BSFS (p=0.016); AMHP: Significant MCAS by week 3 (p=0.024), Rome III (p=0.25), BSFS (p=0.05)	Sham cranial hold (mastoid contact without CRI manipulation)	Sham CV4, no treatment, resting positions, or simple touch	LOS, feeding, GI symptoms, pneumonia, weight gain, hospital cost
Key results	Statistically significant improvement in GMFM total score and WeeFIM mobility domain in OMT group	Generally positive effects reported, especially in quality of life and motor control	Significant improvement in constipation symptoms in both AMHP (p=0.003) and OMT-H (p=0.00014); OMT-H improved MCAS by week 1 vs. AMHP by week 3. Rome III criteria: all OMT-H children relieved of constipation (p=0.004); BSFS normalization in 6/9 (OMT-H) vs. 2/10 (AMHP) (p=0.016 and p=0.05 respectively); 7/9 MCAS sub-parameters improved with OMT-H vs. 2/10 with AMHP.	CV4 group showed significantly greater reduction in heart rate (mean drop 3.11 bpm vs. 1.12 bpm in sham; p=0.036); No significant changes in systolic (p=0.446) or diastolic BP (p=0.799); reduction in HAM-A anxiety scores greater in CV4 group (Δ3.58 vs. Δ2.77) but not statistically significant (p=0.09)	CV4 group showed significantly greater reduction in heart rate (mean drop 3.11 bpm vs. 1.12 bpm in sham; p=0.036); No significant changes in systolic (p=0.446) or diastolic BP (p=0.799); reduction in HAM-A anxiety scores greater in CV4 group (Δ3.58 vs. Δ2.77) but not statistically significant (p=0.09)	Reduced LOS (up to 75 %), improved feeding, weight gain, reduced pneumonia
Statistical significance	p<0.05 for two primary mobility outcomes	Not consistently reported across studies	Small sample size; no quality of life scale utilized; short duration; no blinding; subjective parent reports	Small sample size; short intervention duration; not powered for psychological outcomes; potential placebo effects	Small samples; heterogeneity of methods; most studies lacked control groups; few studied clinical populations	Yes (eg, p<0.001 in several studies)

Table 2: (continued)

Study	Duncan et al. [35]	Jakel and von Hauenschild, [38]	Chatip et al. [40]	Goering et al. [36]	Żurowska et al. [37]	Roland et al. [39]
Limitations	Small sample size, short duration, single-blind, multiple comparisons without correction	Heterogeneous methods, many small studies, varying quality	None reported	None reported	None reported	Many studies single-site; treatment and populations varied
Quality assessment	Moderate: RCT with blinded assessors, but pilot in scope	Low to moderate: due to heterogeneity and lack of robust statistical reporting	Moderate: Small sample, randomization and multiple outcome measures utilized, but limitations exist	Moderate: Controlled with clear outcomes, but limited by size and single treatment exposure	Moderate; Downs and Black scores 17–24/27	Moderate to high (based on RCTs and multicenter data)

This table provides a detailed overview of key studies assessing the use of OMM, including cranial techniques, in various populations. Each study is described by its design, sample size, population characteristics, intervention and comparator details, outcomes measured, key results, statistical significance (if reported), limitations, any noted complications, and an overall assessment of study quality. AMHP, approved mental health professional; BLT, balanced ligamentous tension; BP, blood pressure; bpm, beats per minute; BSFS, bristol stool form scale; CRI, cranial rhythmic impulse; CV4, compression of the 4th ventricle; GI, gastrointestinal; GMFM, gross motor function measure; HAM-A, hamilton anxiety rating scale; LBP, low blood pressure; LOS, length of stay; MCAS, modified constipation assessment scale; MFR, myofascial release; NICU, neonatal intensive care unit; OCM, osteopathic cranial manipulation; OMM, osteopathic manipulative medicine; OMT, osteopathic manipulative treatment; OMT-H, osteopathic manipulative treatment at home; PEDI, pediatric evaluation of disability inventory; RCTs, randomized controlled trials; TTH, tension-type headache; VAS, visual analogue scale; WeeFIM, functional independence measure for children.

motor function. Finally, the study by Chatip et al. [40] showed that OMM had a statistically significant improvement in constipation symptoms and resolved constipation faster than the control group that received abdominal massage. The studies in Table 2 measured the benefits of OMM utilizing both objective and subjective measures. The objective measures utilized were assessments such as gross motor function measure (GMFM), Functional Independence Measure for Children (WeeFIM), Pediatric Evaluation of Disability Inventory (PEDI), Visual Analogue Scale (VAS), Ashworth Scale, Modified Constipation Assessment Scale (MCAS), Rome III Criteria, Bristol Stool Form Scale (BSFS), and Hamilton Anxiety Rating Scale (HAM-A); vitals and length of stay were also measured and compared. The subjective measures utilized were patient reports of quality of life, change in pain, and motor control (Table 2).

Given these positive outcomes, further research in this area could lead to enhanced treatment protocols and, ultimately, a better quality of life for CP patients. Another important direction for future research is the investigation of OMM and its differential effects on adults and children with CP [68]. Adults, especially the elderly, have thinner skin, weaker bones, and less flexibility; therefore, certain treatments, such as high-velocity, low-amplitude (HVLA), should be avoided. Doctors should also avoid treatments that involve a lot of force and compression in children because their joints and tissues are more flexible and still developing. Instead, MFR and counterstrain are preferable for these populations. Comorbidities such as osteoporosis, malignancy, and postoperative alterations must be taken into consideration because they may

serve as contraindications for certain techniques. Understanding these distinctions could help tailor OMM approaches to different age groups, optimizing therapeutic outcomes.

However, the current body of evidence supporting the use of OMM in CP remains limited and should be interpreted with caution. Although several studies have reported improvements in motor function, mobility, and quality of life following OMM treatment, many of these studies have methodological weaknesses that limit their applicability to a general population. Common limitations include small sample sizes and a heavy reliance on subjective measures such as caregiver-reported improvement. These factors can increase the chance of bias and limit a study's reproducibility across a broader CP population. Not all studies supported the efficacy of OMM in CP patients. Attia et al. [33] and Awaad et al. [34] reported that the neurological damage in CP is irreversible and that OMM has limited efficacy in improving outcomes. The current body of evidence supporting the use of OMM in CP remains limited and should be interpreted with caution. Several studies have reported improvements in motor function, mobility, and quality of life following OMM treatment. These findings are often undermined by methodological weaknesses, including small sample sizes, a lack of appropriate control groups, and reliance on subjective measures such as caregiver-reported improvements. In addition, some studies failed to account for confounding interventions, such as concurrent physical or occupational therapy, making it difficult to isolate the specific effects of OMM. These issues increase the risk of bias

and limit reproducibility across the broader CP population. In contrast, other studies have not demonstrated a significant benefit. Taken together, the evidence presents a mixed picture: while some studies suggest potential symptomatic benefit, others highlight minimal or no effect, particularly when methodological flaws are addressed and neurological deficits are considered. This can strengthen the claim that OMM has limited efficacy on neurological deficits.

Several trials lacked proper control groups and did not account for confounding variables such as the use of concurrent pharmaceutical interventions and physical therapy, making it difficult to conclude a patient's treatment success solely on OMM. In order to establish OMM as a credible adjuvant therapy, future studies must prioritize RCTs, adequate sample sizes, standardized treatment protocols, and objective outcome measurements to determine the benefits of OMM over a long period of time.

Limitations

As a limitation of this review, we were not able to successfully retrieve all of the articles due to accessibility restrictions, which may have limited the depth of the review. Additionally, the findings of this review may not be generalizable to all patients with CP.

Future directions

Future research should directly address the methodological and clinical gaps identified in current studies. One important area is structural outcomes such as pelvic obliquity and neuromuscular scoliosis, which remain underexplored. Sacral and pelvic-focused OMM interventions warrant additional trials with standardized protocols to better assess their role in postural alignment and scoliosis progression [67]. Although many studies report improvements in gross motor function and mobility, these findings often rely on caregiver-reported outcomes, which may introduce bias [34, 66]. Motor outcomes also require stronger objective validation. Incorporating objective measures such as gait analysis, electromyography (EMG), and motion capture would help provide more reliable evidence of OMM's impact on neuromuscular control.

Another area that deserves closer study is the differential effect of OMM across age groups. Children and adults with CP face distinct MSK and neuroplastic challenges, suggesting that tailored approaches may optimize outcomes [68]. Stratified studies comparing pediatric and adult populations could help develop age-specific treatment guidelines. In addition, research into psychological and behavioral domains, such as anxiety and stress regulation,

should include validated psychometric tools to better capture OMM's potential holistic benefits [5, 32]. From a methodological standpoint, future studies should focus on improving design quality. Larger, multicenter RCTs with long-term follow-up and well-defined control groups (eg, standard physical and occupational therapy alone) are needed to isolate the specific contribution of OMM. Standardized treatment protocols would also reduce practitioner variability and improve reproducibility [42, 66].

Finally, mechanistic and translational work should expand on developmental imaging and neurophysiological assessments, such as diffusion magnetic resonance imaging (MRI), electroencephalography (EEG), and EMG, to better understand how OMM influences neural plasticity, proprioception, and muscle architecture. Biomarker analyses, including inflammatory and stress markers, may also clarify the systemic pathways involved [5, 26, 27]. Alongside clinical outcomes, economic evaluations are necessary to determine whether OMM can reduce long-term healthcare costs, particularly given the substantial lifetime expenses associated with CP care [58].

Taken together, these directions highlight the need for more rigorous, standardized, and multidisciplinary research. Such work would help determine whether OMM can move beyond an adjunct role and become a more established part of CP care, ultimately improving functional outcomes, quality of life, and economic sustainability for patients and families.

Conclusions

Integrating OMM into CP management may offer clinical and economic benefits. CP is a lifelong condition that causes movement disorders and complications, placing physical, emotional, and financial burdens on patients and families [29, 31, 69]. Standard treatments – medications, therapy, and surgery – manage symptoms but often fail to address holistic patient needs, highlighting the value of complementary therapies like OMM. Techniques such as MFR, cranial manipulation, and soft-tissue therapy provide low-risk interventions that enhance mobility, relieve symptoms, and improve function [35]. Overall, OMM's holistic approach can help improve outcomes by addressing CP's complex challenges. Although further research is needed, existing evidence supports the role of OMM in enhancing patient well-being and function. Expanding OMM access within multidisciplinary care could improve patient-centered treatment while reducing economic burdens by minimizing invasive procedures and long-term medication use. As such, continued research is essential to optimize OMM's integration into CP care and to fully assess its long-term benefits.

Research ethics: Not applicable.

Informed consent: Not applicable.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Use of Large Language Models, AI and Machine Learning

Tools: None declared.

Conflict of interest: None declared.

Research funding: None declared.

Data availability: Raw data may be obtained on request from the corresponding author.

References

- Hallman-Cooper JL, Rocha CF. Cerebral palsy. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. <https://www.ncbi.nlm.nih.gov/books/NBK538147/> [Accessed 24 Feb 2024].
- Trabacca A, Vespino T, Di Liddo A, Russo L. Multidisciplinary rehabilitation for patients with cerebral palsy: improving long-term care. *J Multidiscip Healthc* 2016;9:455–62.
- Babcock MA, Kostova FV, Ferriero DM, Johnston MV, Brunstrom JE, Hagberg H, et al. Injury to the preterm brain and cerebral palsy: clinical aspects, molecular mechanisms, unanswered questions, and future research directions. *J Child Neurol* 2009;24:1064–84.
- Marret S, Lavelanet A, Soni S. Pathophysiology of cerebral palsy. In: *Handbook of clinical neurology*. Amsterdam, Netherlands: Elsevier; 2013, 111:169–76 pp.
- Abraham C, Sloan SNB, Coker C, Freed B, McAuliffe M, Nielsen H, et al. Osteopathic manipulative treatment as an intervention to reduce stress, anxiety, and depression in first responders: a pilot study. *Mo Med* 2021;118:435–41.
- Roberts A, Harris K, Outen B, Bukvic A, Smith B, Schultz A, et al. Osteopathic manipulative medicine: a brief review of the hands-on treatment approaches and their therapeutic uses. *Medicines (Basel)* 2022;9:33.
- Seffinger MA, Hruby R, Willard FH. *Osteopathic principles and practice: a comprehensive guide*, 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2018.
- Bagagiolo D, Rosa D, Borrelli F. Efficacy and safety of osteopathic manipulative treatment: an overview of systematic reviews. *BMJ Open* 2022;12:e053468.
- Flodine TE, Thomas M. Osteopathic manipulative treatment: inhaled rib dysfunction. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. <https://www.ncbi.nlm.nih.gov/books/NBK560751/> [Accessed 8 Aug 2023].
- National Institutes of Health (NIH). Cerebral palsy. [https://www.ninds.nih.gov/health-information/disorders/cerebral-palsy#:~:text=The%20muscles%20and%20limbs%20affected,and%20bone%20enlargement%20\(osteoporosis\)](https://www.ninds.nih.gov/health-information/disorders/cerebral-palsy#:~:text=The%20muscles%20and%20limbs%20affected,and%20bone%20enlargement%20(osteoporosis)) [Accessed 5 March 2025].
- Graham HK, Rosenbaum P, Paneth N, Dan B, Lin JP, Damiano DL, et al. Cerebral palsy. *Nat Rev Dis Primers* 2016;2:15082.
- Paton MCB, Finch-Edmondson M, Dale RC, Fahey MC, Nold-Petry CA, Nold MF, et al. Persistent inflammation in cerebral palsy: pathogenic mediator or comorbidity? A scoping review. *J Clin Med* 2022;11:7368.
- Patel DR, Neelakantan M, Pandher K, Merrick J. Cerebral palsy in children: a clinical overview. *Transl Pediatr* 2020;9:S125–35.
- Korzeniewski SJ, Slaughter J, Lenski M, Haak P, Paneth N. The complex aetiology of cerebral palsy. *Nat Rev Neurol* 2018;14:528–43.
- MacLennan AH, Blair E, Gibson CS. Cerebral palsy: causes, pathways, and the role of genetic variants. *Am J Obstet Gynecol* 2015;213:779–88.
- Novak I, Morgan C, Fahey M, Finch-Edmondson M, Galea C, Hines A, et al. State of the evidence traffic lights 2019: systematic review of interventions for preventing and treating children with cerebral palsy. *Curr Neurol Neurosci Rep* 2020;20:3.
- Paul S, Nahar A, Bhagawati M, Kunwar AJ. A review on recent advances of cerebral palsy. *Oxid Med Cell Longev* 2022;2022:2622310.
- Chin EM, Gwynn HE, Robinson S, Hoon AH Jr. Principles of medical and surgical treatment of cerebral palsy. *Neurol Clin* 2020;38:397–416.
- Llamas-Ramos R, Sánchez-González JL, Llamas-Ramos I. Robotic systems for the physiotherapy treatment of children with cerebral palsy: a systematic review. *Int J Environ Res Public Health* 2022;19:5116.
- Cholewicki J, Popovich MJ, Reeves NP, DeStefano LA, Rowan JJ, Francisco TJ, et al. The effects of osteopathic manipulative treatment on pain and disability in patients with chronic neck pain: a single-blinded randomized controlled trial. *Pharm Manag PM R* 2022;14:1417–29.
- Licciardone JC, Schultz MJ, Amen B. Osteopathic manipulation in the management of chronic pain: current perspectives. *J Pain Res* 2020;13:1839–47.
- Franke H, Franke JD, Fryer G. Osteopathic manipulative treatment for nonspecific low back pain: a systematic review and meta-analysis. *BMC Musculoskelet Disord* 2014;15:286. <https://doi.org/10.1093/eurpub/cku130>.
- Furlan AD, Yazdi F, Tsertsvadze A, Gross A, Van Tulder M, Santaguida L, et al. A systematic review and meta-analysis of efficacy, cost-effectiveness, and safety of selected complementary and alternative medicine for neck and low-back pain. *Evid Based Complement Alternat Med* 2012;2012:953139.
- Jara Silva CE, Joseph AM, Khatib M, Knafo J, Karas M, Krupa K, et al. Osteopathic manipulative treatment and the management of headaches: a scoping review. *Cureus* 2022;14:e27830.
- Terrell ZT, Moudy SC, Hensel KL, Patterson RM. Effects of osteopathic manipulative treatment vs. osteopathic cranial manipulative medicine on parkinsonian gait. *J Osteopathic Med.* 2022;122:243–51.
- Miller AH, Raison CL. The role of inflammation in depression: from evolutionary imperative to modern treatment target. *Nat Rev Immunol* 2016;16:22–34.
- Autry AE, Monteggia LM. Brain-derived neurotrophic factor and neuropsychiatric disorders. *Pharmacol Rev* 2012;64:238–58.
- Pariante CM, Lightman SL. The HPA axis in major depression: classical theories and new developments. *Trends Neurosci* 2008;31:464–8.
- Van Der Slot WMA, Oosterhuis HJ, Geytenbeek J, Bergen MP, Hilberink SR, Stam HJ, et al. Chronic pain, fatigue, and depressive symptoms in adults with spastic bilateral cerebral palsy. *Dev Med Child Neurol* 2012;54:836–42.
- Ramstad K, Jahr P, Rannestad T, Diseth TH. Parent-reported participation in children with cerebral palsy: the contribution of recurrent musculoskeletal pain and child mental health problems. *Dev Med Child Neurol* 2012;54:829–35.
- Ferro MA, Harel F, Martel A. Trajectories of depressive symptoms during the transition to young adulthood: the role of chronic illness. *J Affect Disord* 2015;174:594–601.
- Sienko SE. An exploratory study investigating the multidimensional factors impacting the health and well-being of young adults with cerebral palsy. *Disabil Rehabil* 2018;40:660–6.
- Attia M, Ibrahim FA, Elsady MA, Khorkhash MK, Rizk MA, Shah J, et al. Cognitive, emotional, physical, and behavioral stress-related

- symptoms and coping strategies among university students during the third wave of COVID-19 pandemic. *Front Psychiatry* 2022;13:933981.
34. Awaad Y. Management of spasticity and cerebral palsy update. In: *Cerebral palsy – updates*. London: IntechOpen; 2023.
 35. Duncan B, McDonough-Means S, Worden K, Schnyer R, Andrews J, Meaney FJ. Effectiveness of osteopathy in the cranial field and myofascial release versus acupuncture as complementary treatment for children with spastic cerebral palsy: a pilot study. *J Osteopath Med* 2008;108:559–70.
 36. Goering E, Herner M, Smith M, Galka M, Kammerzell S, Best K, et al. Effects of compression of the 4th ventricle (CV4) treatment on medical student anxiety. *AAO J* 2021;31:55–60.
 37. Żurowska A, Malak R, Kołcz-Trzęsicka A, Samborski W, Paprocka-Borowicz M. Compression of the fourth ventricle using a craniosacral osteopathic technique: a systematic review of the clinical evidence. *Evid Based Complement Alternat Med* 2017;2017:2974962.
 38. Jakel A, von Hauenschild P. Therapeutic effects of cranial osteopathic manipulative medicine: a systematic review. *J Osteopath Med* 2011;111: 685–93.
 39. Roland H, Brown A, Rousselot A, Freeman N, Wieting J, Bergman S, et al. Osteopathic manipulative treatment decreases hospital stay and healthcare cost in the neonatal intensive care unit. *Medicines* 2022;9:49.
 40. Chatip AT, Acar G, Akçay AA. Comparison of the effects of abdominal massage and osteopathic manipulative treatment home program on constipation in children with cerebral palsy. *JGH Open* 2024;8:e13102.
 41. Dwyer C, Norkus S, Kingsley A. Manual therapy and cerebral palsy: a narrative literature review. *J Int Acad Neuromusculoskelet Med*. 2023; 20. Available from: <https://ianmedicine.org/wp-content/uploads/2023/06/Dwyer.pdf>.
 42. Posadzki P, Lee MS, Ernst E. Osteopathic manipulative treatment for pediatric conditions: a systematic review. *Pediatrics* 2013;132:140–52.
 43. Cleveland Clinic. Muscle dystrophy; 2022. Available from: <https://my.clevelandclinic.org/health/diseases/22310-muscle-atrophy>.
 44. Zhang H, Qi G, Wang K, Yang J, Shen Y, Yang X, et al. Oxidative stress: roles in skeletal muscle atrophy. *Biochem Pharmacol* 2023;214:115664.
 45. Handsfield GG, Williams S, Khoo S, Lichtwark G, Stott NS. Muscle architecture, growth, and biological remodeling in cerebral palsy: a narrative review. *BMC Musculoskelet Disord* 2022;23:233.
 46. Yao S, Hassani J, Gagne M, George G, Gilliar W. Osteopathic manipulative treatment as a useful adjunctive tool for pneumonia. *J Vis Exp* 2014;50687. <https://doi.org/10.3791/50687>.
 47. Remien K, Woo MJ, Vilella RC. Osteopathic manipulative treatment: lymphatic procedures. In: *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. <https://www.ncbi.nlm.nih.gov/books/NBK559051/> [Accessed 29 Jan 2024].
 48. Whelan G, Johnston R, Millward C, Edwards DJ. The immediate effect of osteopathic cervical spine mobilization on median nerve mechanosensitivity: a triple-blind, randomized, placebo-controlled trial. *J Bodyw Mov Ther* 2018;22:252–60.
 49. Bordon B, Escher AR Jr. Osteopathic principles: the inspiration of every science is its change. *Cureus* 2021;13:e12478.
 50. Sari DM, Wijaya LC, Sitorus WDR, Dewi MM. Psychological burden in spinal muscular atrophy patients and their families: a systematic review. *Egypt J Neurol Psychiatry Neurosurg* 2022;58:140.
 51. Fornari M, Carnevali L, Sgoifo A. Single osteopathic manipulative therapy session dampens acute autonomic and neuroendocrine responses to mental stress in healthy male participants. *J Osteopath Med* 2017;117:559–67.
 52. Vitrikas K, Dalton H, Breish D. Cerebral palsy: an overview. *Am Fam Physician* 2020;101:213–20.
 53. Snider KT, Jorgensen DJ. Billing and coding for osteopathic manipulative treatment. *J Osteopath Med* 2009;109:409–13.
 54. Heidelbaugh JJ, Riley M, Habetler JM. 10 billing & coding tips to boost your reimbursement: keep more of what you earn by avoiding these costly coding missteps. *J Fam Pract* 2008;57:724–31.
 55. Cooley D, Bailey J, Jermyn R. Cost comparison of osteopathic manipulative treatment for patients with chronic low back pain. *J Osteopath Med* 2021;121:635–42.
 56. Pelletier J, Capistrant T, Nordt SP. Osteopathic manipulation and its applicability in the emergency department: a narrative review. *Am J Emerg Med* 2024;84:74–80.
 57. Pollock RF, Shergill S, Carion PL, von Oppen N, Agirrezabal I, Brennan VK. Advances in delivery of selective internal radiation therapy (SIRT): economic and logistical effects of same-stay work-up and procedure in the treatment of unresectable liver tumors in England. *Adv Ther* 2023;40:294–309.
 58. Centers for Disease Control and Prevention (CDC). Economic costs associated with mental retardation, cerebral palsy, hearing loss, and vision impairment – United States, 2003. *MMWR Morb Mortal Wkly Rep* 2004;53:57–9.
 59. Jespersen LN, Michelsen SI, Tjørnhøj-Thomsen T, Svensson MK, Holstein BE, Due P. Living with a disability: a qualitative study of associations between social relations, social participation, and quality of life. *Disabil Rehabil* 2019;41:1275–86.
 60. Michelsen SI, Uldall P, Hansen T, Madsen M. Social integration of adults with cerebral palsy. *Dev Med Child Neurol* 2006;48:643–9.
 61. Pettersson K, Rodby-Bousquet E. Living conditions and social outcomes in adults with cerebral palsy. *Front Neurol* 2021;12:749389.
 62. Mayo-Wilson E, Montgomery P, Dennis J. Personal assistance for adults (19-64) with both physical and intellectual impairments. *Cochrane Database Syst Rev* 2008;2008:CD006860.
 63. Alriksson-Schmidt A, Hägglund G, Rodby-Bousquet E, Westbom L. Follow-up of individuals with cerebral palsy through the transition years and description of adult life: the Swedish experience. *J Pediatr Rehabil Med* 2014;7:53–61.
 64. Schenker R, Coster W, Parush S. Personal assistance, adaptations and participation in students with cerebral palsy mainstreamed in elementary schools. *Disabil Rehabil* 2006;28:1061–9.
 65. Chen YY, Hsieh CI, Chung KP. Continuity of care, follow-up care, and outcomes among breast cancer survivors. *Int J Environ Res Public Health* 2019;16:3050.
 66. Wyatt K, Edwards V, Franck L, Britten N, Creanor S, Maddick A, et al. Cranial osteopathy for children with cerebral palsy: a randomised controlled trial. *Arch Dis Child* 2011;96:505–12.
 67. Yen W, Gartenberg A, Cho W. Pelvic obliquity associated with neuromuscular scoliosis in cerebral palsy: cause and treatment. *Spine Deform* 2021;9:1259–65.
 68. Sees JP. Osteopathic manipulative treatment and acupuncture in cerebral palsy. In: Miller F, Bachrach S, Lennon N, O’Neil M, editors. *Cerebral palsy*. London: Springer; 2020:91–1 pp.
 69. Ramstad K, Høiby A, Sørensen L, Diseth TH. Mental health, health-related quality of life, and recurrent musculoskeletal pain in children with cerebral palsy 8-18 years old. *Disabil Rehabil* 2012;34:1589–95.