Neuromusculoskeletal Medicine (OMT) Review Article

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Impact of osteopathic manipulative techniques on the management of dizziness caused by neuro-otologic disorders: systematic review and meta-analysis

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Abstract

Context: Osteopathic manipulative treatment (OMT) has been utilized by osteopathic clinicians as primary or adjunctive management for dizziness caused by neuro-otologic disorders. To our knowledge, no current systematic reviews provide pooled estimates that evaluate the impact of OMT on dizziness.

Objectives: We aimed to systematically evaluate the effectiveness and safety of OMT and analogous techniques in the treatment of dizziness.

Methods: We performed a literature search in CINAHL, Embase, MEDLINE, Allied and Complementary Medicine Database (AMED), EMCare, Physiotherapy Evidence Database (PEDro), PubMed, PsycINFO, Osteopathic Medicine Digital Library (OSTMED.DR), and Cochrane Central Register of Controlled Trials (CENTRAL) from inception to March 2021 for randomized controlled trials (RCTs) and prospective or retrospective observational studies of adult patients experiencing dizziness from neuro-otological disorders. Eligible studies compared the effectiveness of OMT or OMT analogous techniques with a comparator intervention, such as a sham manipulation, a different manual technique, standard of care, or a nonpharmacological intervention like exercise or behavioral therapy. Assessed outcomes included disability associated with dizziness, dizziness severity, dizziness frequency, risk of fall, improvement in quality of life (QOL), and return to work (RTW). Assessed harm outcomes included all-cause dropout (ACD) rates, dropouts due to inefficacy, and adverse events. The meta-analysis was based on the similarities between the OMT or OMT analogous technique and the comparator interventions. The risk of bias (ROB) was assessed utilizing a modified version of the Cochrane Risk of Bias Tool for RCTs and the Cochrane Risk of Bias in Non-randomized Studies – of Interventions (ROBINS-I) for observational studies. The quality of evidence was determined utilizing the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach.

Results: There were 3,375 studies identified and screened, and the full text of 47 of them were reviewed. Among those, 12 (11 RCTs, 1 observational study, n=367 participants) met the inclusion criteria for data extraction. Moderate-quality evidence showed that articular OMT techniques were associated with decreases (all $p<0.01$) in disability associated with dizziness (n=141, mean difference [MD]=−11, 95% confidence interval [CI]=−16.2 to −5.9), dizziness severity

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(n=158, MD=−1.6, 95% CI=−2.4 to −0.7), and dizziness frequency (n=136, MD=−0.6, 95% CI=−1.1 to −0.2). Low-quality evidence showed that articular OMT was not associated with ACD rates (odds ratio [OR]=2.2, 95% CI=0.5 to 10.2, p=0.31). When data were pooled for any type of OMT technique, findings were similar; however, disability associated with dizziness and ACD rates had high heterogeneity (I^2=59 and 46%). No studies met all of the criteria for ROB.

Conclusions: The current review found moderate-quality evidence that treatment with articular OMT techniques was significantly associated with decreased disability associated with dizziness, dizziness severity, and dizziness frequency. However, our findings should be interpreted cautiously because of the high ROB and small sample sizes in the eligible studies.

Keywords: dizziness; effectiveness; meta-analysis; osteopathic manipulative treatment; safety; systematic review; vertigo.

Dizziness due to neuro-otological disorders is a common medical problem with a lifetime prevalence of 30% [1]. It also accounts for 2–5% of total primary care physician visits [2, 3]. The prevalence of dizziness increases with age [4], and approximately 1 in 3 older patients and 1 in 5 working-age adults experience vertigo [5, 6]. Older patients experiencing dizziness also have a 31% higher risk of nonosteoporotic fractures [6–12]. Additionally, people who experience dizziness have a reduced rate of independence because of difficulties performing daily activities, psychological and social impairments [13], and work absenteeism leading to socioeconomic loss [14]. In the United States, the direct and indirect healthcare costs from loss of productivity due to dizziness and associated complications are estimated to be $23.3 billion annually [15, 16].

When utilized for the treatment of dizziness, the goal of osteopathic manipulative treatment (OMT) is to normalize impaired structure-function relationships or homeostatic mechanisms contributing to the underlying condition [17, 18]. Utilized in various manual medicine disciplines, OMT and analogous techniques have emerged as a potential primary intervention or adjunctive treatment for dizziness. However, studies investigating the effectiveness of these techniques are sparse or have marked limitations, such as lack of statistical power [19, 20] or optimal follow-up duration [21]. Because meta-analyses and systematic reviews can report pooled estimates of interventions systematically and transparently, their use increases power and provides more precise results [22]. For example, a systematic review by Veloso et al. [23] investigated the effect of OMT on postural balance; however, the methods were not explicitly reported, and the quality of evidence was not appraised. Therefore, the purpose of the current review was to review the existing literature and to determine the quality of evidence from pooled estimates of the effect of OMT and OMT analogous techniques on the patient important outcomes such as the severity of dizziness symptoms, the frequency of dizziness symptoms, disability due to dizziness, and harm outcomes. For the purposes of this review, dizziness refers to a spinning sensation or distorted sense of self-motion with normal head movements that leads to postural instability and is caused by the neuro-otological condition.

Methods

Search strategy and eligibility criteria

Detailed methods and statistical analyses for the current review were published previously [24]. The study protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO Registration: CRD42020208302). We conducted the meta-analysis according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [25], PRISMA harm checklists [26, 27], the Cochrane Handbook for Systematic Reviews of Interventions [28], and modified Effective Practice and Organisation of Care (EPOC) tools [29]. We performed a literature search in the following databases from inception to February 2021: Cumulative Index to Nursing and Allied Health Literature (CINAHL), Embase, MEDLINE, Allied and Complementary Medicine Database (AMED), Emcare, Physiotherapy Evidence Database (PEDro), PubMed, PsycINFO, Osteopathic Medicine Digital Library (OSTMED.DR), and Cochrane Central Register of Controlled Trials (CENTRAL) databases. The search strategy utilized in the current review is reported in Supplementary Table S1.

The eligibility criteria for the current review included randomized controlled trials (RCTs) and prospective or retrospective observational studies of patients aged 18 years or older who were experiencing dizziness due to neuro-otological disorders. Eligible studies had to compare the effectiveness of OMT or OMT analogous techniques to a comparator intervention. Comparator interventions could include sham manipulation, which is a palpatory contact or protocol that is not intended to produce a therapeutic response, a standard of care, or a nonpharmacological intervention, such as exercise or behavioral therapies. Studies were excluded if the etiology of the dizziness was caused by: vascular, neoplastic, or malignant causes; seizures; peripheral neuropathies; or postural dysfunctions without a neuro-otological component. Studies that focused on cardiovascular symptoms, dizziness from medication use, psychological causes, vascular malformations, or metabolic causes were also excluded. In addition, studies were excluded if the authors reported aggregated outcome scores or if the study had no comparator arm. We also amended our original PROSPERO protocol to include trials that assigned less than 10 patients to each intervention arm.

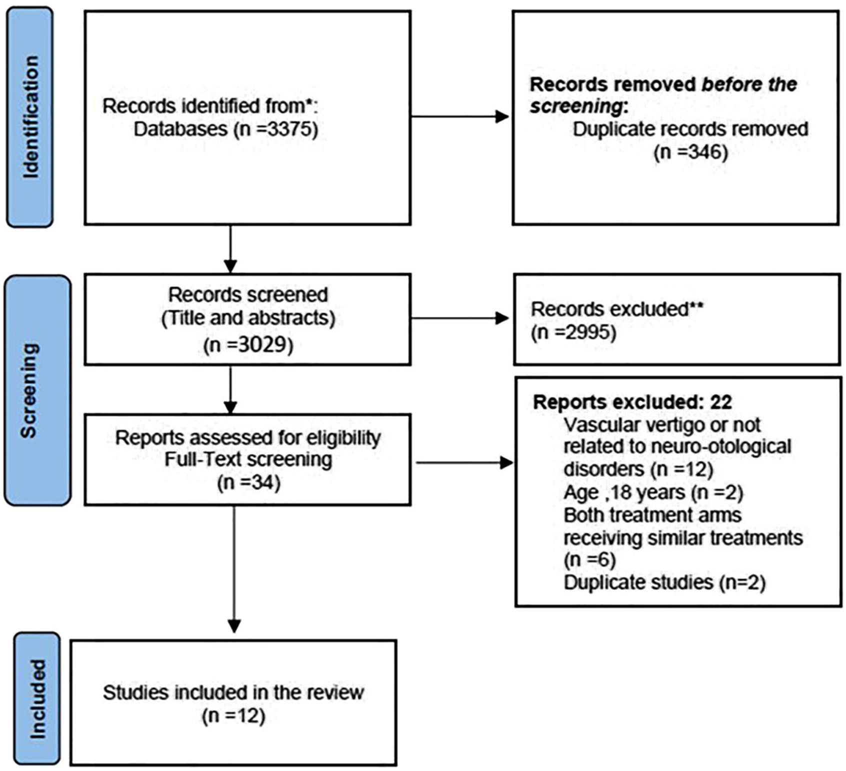

Figure 1: PRISMA flow diagram for the screening and eligible studies. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Screening and data synthesis

Article screening included a review of the title and abstract. For studies meeting eligibility criteria, the full text was reviewed, and the data were extracted by two independent reviewers. Any conflicts were resolved with the consensus and the arbitration of the third reviewer if needed. Data were extracted for demographic characteristics (age, sex), intervention details, outcomes data, and the number of events associated with all-cause dropout (ACD) rates. Patient outcomes of interest were disability associated with dizziness as measured by the Dizziness Handicap Inventory, dizziness severity, dizziness frequency, risk of falls, quality of life (QOL), and return to work (RTW). Harm outcomes included ACD rates, dropouts due to inefficacy, and dropouts due to adverse events.

Data for specific OMT techniques utilized alone or as part of a larger treatment protocol were extracted. For the current review, OMT analogous techniques were defined as techniques that are equivalent in procedure to published osteopathic techniques [30]. For example, techniques classified as articular techniques are equivalent in procedure to low-velocity, moderate-amplitude articulatory OMT techniques [30]. Analogous techniques are utilized in various manual medicine disciplines, such as chiropractic, physical therapy, and massage; however, the specific names of the analogous techniques may differ based on the discipline [31, 32]. The inclusion of OMT analogous techniques was determined by the two expert osteopathic reviewers (KS and JK), and analogous techniques were categorized into a specific OMT technique category for pooling. To address the issue of high heterogeneity that was a major limitation in previous systematic reviews [33–35], we pooled studies specific to OMT and comparator types for each outcome. This approach has been previously validated [36, 37].

Data analysis

For the pooled meta-analysis, the effect estimate was calculated as a weighted mean difference (MD) and 95% confidence interval (CI) for continuous outcomes. Effect estimates of dizziness severity and dizziness frequency were reported in the reviewed studies utilizing different outcomes measurement scales. Therefore, we converted that data to the same scale for analysis (0–10 points for dizziness severity outcomes, and 0–5 points for dizziness frequency outcomes), utilizing the formulas of Luo et al. [38] and Shi et al. [39] One study [40] reported outcomes estimates with median and interquartile range, so we converted that data to mean and standard deviation utilizing the equations of Luo et al. [38] and Shi et al. [39] As part of the sensitivity analyses, this study [40] was also excluded from the pooled analysis to investigate the effect of the imputation in sensitivity analysis for dizziness severity and dizziness frequency. Binary outcomes (ACD) were reported utilizing an odds ratio (OR) with an associated 95% CI. Sensitivity analysis was performed by pooling different OMT types, as previously reported [33–35]. Because of the limited number of studies, we also performed a subgroup analysis investigating the lack of blinding of the data analyst for the dizziness severity outcome. All statistical analyses were performed with the R package meta [41] and reported utilizing a random effect model. $p<0.05$ was considered significant.

We assessed the quality of evidence in the pooled estimates utilizing the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach [42, 43]. The five categories assessed with this approach are risk of bias (ROB), inconsistency, indirectness, imprecision, and publication bias. The ROB for RCTs was assessed utilizing a modified Cochrane ROB tool [44, 45]. Specifically, this tool evaluated the following: allocation concealment; blinding of participants, clinicians, data collectors, and outcomes assessors; and

Table 1: Summary characteristics of reviewed studies.

Study	Participants[a]	Type of study	Diagnosis	Concurrent medications/ treatments allowed	Duration of study	Missing data accounted for
Atay et al. [49]	n=30 42.2 y 80% female, 20% male	Observational-prospective	Vertigo	Treatment group not permitted other treatments during study. Control group permitted medical treatments	42	No
Carrasco-Uribarren et al. [50]	n=40 54 y 80% female, 20% male	Parallel-arm RCT	Cervicogenic dizziness (excluded isolated vestibular causes)	Patients who received cervical treatment within 3 mo excluded	28	Yes
Di Francisco-Donoghue et al. [51]	n=9 72 y 44.4% female, 55.6% male	Crossover RCT	PD with disequilibrium	Anti-Parkinson medications with 12 h washout before outcome measures	42	No
do Nascimento Oliveira et al. [52]	n=20 33.3 y 100% female	Parallel-arm RCT	Vertigo	No	Randomization period differed per arm	NR
Fraix et al. [53]	n=26 52.2 y 73.1% female, 26.9% male	Parallel-arm RCT	Vertigo (excluded meniere disease)	VRT not permitted during study; manual therapy not permitted during or 3 mo before study	90	No
Heikkilä et al. [54]	n=14 36 y 57.1% female, 42.9% male	Crossover RCT	Cervicogenic dizziness or vertigo + neck pain (excluded isolated vestibular causes)	NR	Randomization period differed per arm	NR
Karlberg et al. [40]	n = 17 38.1 y 88.2% female, 11.8% male	Crossover RCT	Cervicogenic dizziness or vertigo + neck pain (excluded isolated vestibular causes)	NSAIDs permitted; 12 h washout period for alcohol + sedatives before outcome measures	56	NR
Kendall et al. [55]	n=24 73.4 y 45.5% female, 54.5% male	Crossover RCT	Cervicogenic dizziness or vertigo + neck pain (excluded isolated vestibular causes)	No	42	No
Papa et al. [56]	n=40 57.5 y 32.3% female, 67.7% male	Parallel-arm RCT	Vertigo	NR	28	No
Reid et al. [58]	n=34 63.5 y 61.8% female, 38.2% male	Parallel-arm RCT	Cervicogenic dizziness (excluded BPPV or meniere disease)	No	112	Yes
Reid et al. [57]	n=86 62.2 y 50% female, 50% male	Parallel-arm RCT	Cervicogenic dizziness (excluded BPPV or meniere disease)	No	365	Yes
Sun et al. [59]	n=27 51.8 y 59.3% female, 40.7% male	Parallel-arm RCT	Meniere disease	5 d Washout period for any treatment before study	Not clear	No

[a]Data are reported as number of enrolled participants, mean age of participants, and sex of participants; BPPV, benign paroxysmal positional vertigo; NR, not reported; NSAID; nonsteroidal anti-inflammatory drug; PD, parkinson disease; RCT, randomized controlled trial; VRT, vestibular rehabilitation therapy.

Table 2: Risk of bias analysis of the reviewed studies.

Randomized controlled trials								
Study	**Random sequence generation**	**Allocation concealment**	**Blinding of participants**	**Blinding of healthcare provider**	**Blinding of outcome assessors**	**Dropout >20%**	**Selective reporting**	**ITT/ LOCF**
Carrasco-Uribarren et al. [50]	LR	LR	HR	HR	HR	LR	LR	LR
DiFrancisco-Donoghue et al. [51]	HR	HR	HR	HR	LR	LR	LR	HR
do Nascimento Oliveira et al. [52]	HR	HR	HR	HR	HR	HR	LR	HR
Fraix et al. [53]	HR	HR	HR	HR	LR	LR	LR	HR
Heikkilä et al. [54]	HR	HR	HR	HR	HR	HR	LR	HR
Karlberg et al. [40]	HR	HR	HR	HR	LR	HR	LR	HR
Kendall et al. [55]	LR	LR	LR	HR	LR	LR	LR	HR
Papa et al. [56]	LR	LR	LR	HR	LR	LR	LR	HR
Reid et al. [58]	LR	LR	LR	HR	LR	LR	LR	LR
Reid et al. [57]	LR	LR	LR	HR	LR	LR	LR	LR
Sun et al. [59]	HR	HR	HR	HR	HR	HR	LR	HR

Observational study							
Study	**Matching of variables**	**Was selection of exposed and nonexposed cohorts from the same population?**	**Can we be confident in the assessment of exposure?**	**Can we be confident in the assessment of presence or absence of prognostic factors?**	**Were co-interventions similar between groups?**	**Was follow-up of cohorts adequate?**	**Can we be confident in the assessment of outcome?**
Atay et al. [49]	HR	LR	LR	HR	HR	LR	LR

A modified version of the Cochrane risk of bias tool was utilized for reviewed randomized controlled trails and the Cochrane Risk of Bias in Non-randomized Studies – of Interventions (ROBINS-I) was utilized for the observational study; HR, high risk of bias; ITT, intention-to-treat; LOCF, last observation carried forward; LR, low risk of bias.

incomplete outcomes data. The ROB for observational studies was assessed utilizing the Cochrane Risk of Bias in Non-randomized Studies – of Interventions (ROBINS-I) tool [46]. Heterogeneity of the pooled studies was assessed with the forest plot and I^2 statistics [47, 48]. The precision of the effects was measured with the 95% CI and whether the CI included the line of no effect. None of the pooled analyses included 10 or more studies, so we were unable to assess publication bias.

Results

Review studies

Our literature search of the 10 databases found 3,375 studies investigating OMT and OMT analogous techniques for the treatment of dizziness (Figure 1). Among those, 3,310 were excluded and 47 had the full text reviewed. Among those 47 studies, 12 (n=367 participants) studies met our inclusion criteria for data extraction.

A summary of the reviewed studies is presented in Table 1. The median age of participants was 53 years (range, 33–73.4 years); 60.5% were female, and 39.5% were male. Among the 12 reviewed studies, only 1 study [49] was an observational study (n=30); the other 11 studies were RCTs [40, 50–59]. Six studies [52, 54–58] did not allow concomitant medications or report the use of medicines to manage dizziness. Only 3 studies [50, 57, 58] accounted for missing participant data. No studies reported on the RTW outcome.

Supplementary Table S2 summarizes the OMT and the analogous interventions utilized in the reviewed studies, and it categorizes the intervention into a specific OMT technique category for meta-analysis. Four studies reported an OMT protocol that utilized multiple OMT technique types without focusing on a particular category of techniques [49, 51, 53, 56]. Eight studies described OMT protocols that focused on a specific technique category: 4 on articular

Table 3: GRADE quality of evidence for the pooled analyses.

Outcome	No. of studies (participants)	Risk of bias	Inconsistency	Imprecision	Indirectness	Publication bias	Pooled effect estimate[a]	Quality of evidence
Disability associated with dizziness[b]	3 (141)	−	+	+	+	Not detected	−11.1 (−16.2 to −5.9)	Moderate
Dizziness severity	4 (158)	−	+	+	+	Not detected	−1.4 (−2.1 to −0.6)	Moderate
Dizziness frequency	3 (136)	−	+	+	+	Not detected	−0.7 (−1.1 to −0.3)	Moderate
All-cause dropout rates	3 (141)	−	+	−	+	Not detected	2.2 (0.5–10.2)	Low

GRADE, grading of recommendations assessment development, and evaluations. The quality of evidence in the pooled estimates was assessed utilizing the GRADE approach. [a]Pooled effect estimates are reported as mean difference and associated 95% confidence interval (CI) for disability associated with dizziness, dizziness severity, and dizziness frequency, and as an odds ratio and associated 95% CI for all-cause dropout rates. [b]Disability associated with dizziness was assessed with the Dizziness Handicap Inventory.

OMT [40, 55, 57, 58]; 2 on high-velocity, low-amplitude techniques [50, 54]; 1 on osteopathic cranial manipulative medicine [52]; and 1 on progressive inhibition of neuromuscular structures [50]. Six studies utilized OMT analogous techniques [40, 50, 55, 57–59]. For comparator interventions, 5 studies utilized sham treatment [52, 55–58], 3 utilized control [40, 53, 54], 2 utilized pharmacological agents [49, 54], and 1 utilized counseling [51]. Fraix et al. [53] was a four-arm RCT that compared OMT with vestibular rehabilitation therapy, OMT combined with vestibular rehabilitation therapy, and no intervention.

Table 2 summarizes the ROB for the reviewed studies. None of the studies met all of the criteria for ROB, and 2 studies [54, 59] had high ROB for all assessed categories.

Pooled meta-analysis

Among the 12 reviewed studies, pooled analyses could only be performed for the outcomes of disability associated with dizziness, dizziness severity, dizziness frequency, and ACD rates. The GRADE evidence for pooled studies is presented in Table 3.

For disability associated with dizziness, 3 studies [55, 57, 58] (n=141) were pooled, and outcomes were compared for articular OMT techniques between the outcome and control comparator. High-quality evidence showed a reduction in the Dizziness Handicap Inventory score (score ranges from 0–100; high score indicates more severe disability) with articular OMT techniques (MD=−11.1, 95% CI=−16.2 to −5.9, p<0.01) (Supplementary Figure S1A). For the sensitivity analysis, 7 studies [50, 53, 55–59] (n=260) were pooled, and outcomes were compared for any type of OMT between the outcome and control. Any OMT type was associated with a decrease in disability associated with dizziness (MD=−16.6, 95% CI=−24.6 to −8.5, p<0.01) (Supplementary Figure S1B). However, heterogeneity among studies was high (I^2=59%).

For dizziness severity, 4 studies [40, 55, 57, 58] (n=158) were pooled, and the outcomes compared for articular OMT techniques between the outcome and control comparator. Moderate-quality evidence showed a reduction in dizziness severity with articular OMT techniques (MD=−1.6, 95% CI=−2.4 to −0.7, p<0.01) (Supplementary Figure S2A). For the sensitivity analysis, 5 studies [40, 50, 55, 57, 58] (n=198) were pooled, and the outcomes compared for any OMT technique type between the outcome and control. Any OMT type was also associated with improved outcomes (MD=−1.7, 95% CI=−2.3 to −1.0, p<0.01) (Supplementary Figure S2B). Heterogeneity among studies was 13%. Subgroup analysis for this outcome to evaluate blinding of the data analyst found no subgroup effect (Supplementary Figure S3).

For dizziness frequency, 3 studies [40, 57, 58] (n=136) were pooled, and the outcomes compared for articular OMT techniques between the outcome and control comparator. Moderate-quality evidence showed a reduction in dizziness frequency with articular OMT techniques (MD=−0.6, 95% CI=−1.1 to −0.2, p<0.01) (Supplementary Figure S4). There were no additional studies for this outcome, so the sensitivity analysis was not performed.

To evaluate the conversion of Karlberg et al. [40] data, analyses for articular OMT techniques between the outcome and the control were repeated for dizziness severity and dizziness frequency, excluding that study [40]. The association of articular OMT with the dizziness severity (MD=−1.2, 95% CI=−2.0 to −0.4, p<0.01) (Supplementary Figure S5) and dizziness frequency (MD=−0.6, 95% CI=−1.1 to −0.2, p<0.01) (Supplementary Figure S6) remained similar.

For ACD rates, 3 studies [55, 57, 58] (n=142) were pooled, and the outcomes compared for articular OMT techniques between the outcome and control comparator. Low-quality evidence showed a nonsignificant association of ACD dropout rates with articular OMT techniques (OR=2.2, 95% CI=0.5 to 10.2, p=0.31) (Supplementary Figure S7A). For the sensitivity analysis, 6 studies [53, 55–59] (n=217) were pooled, and the outcomes compared for any OMT technique type between the outcome and control. Any OMT type was not associated with ACD rates (OR=0.4, 95% CI=0.1–1.7, p=0.22); however, heterogeneity was high among the pooled studies (I^2=46%) (Supplementary Figure S7B). A second sensitivity analysis pooled 2 studies [51, 53] (n=28) and compared outcomes for any OMT type between the outcome and a nonpharmacological comparator. Any OMT type was not associated with ACD rates (OR=1.4, 95% CI=0.2–14.1, p=0.75) (Supplementary Figure S7C).

Nonpooled outcomes of reviewed studies

Supplementary Table S3 summarizes the outcomes variables of the reviewed studies that could not be included in the pooled analyses. One study (n=20) investigated the effect of cranial OMT on dizziness symptoms [52]. All patients in the OMT group had improved symptoms, and 2 patients in the control group did. The risk of falls was investigated in 1 observational study [48] (n=30) and in 2 RCTs [51, 55] (n=40). Although outcomes for OMT and the control comparators in all 3 studies were different, only the cranial plus OMT [49] intervention was associated with a decreased risk of falls risk when compared with control (diphenhydramine). Kendall et al. [55] (n=22) investigated the impact of articular OMT on QOL utilizing the physical component summary (PCS) and mental component summary (MCS) scores of the 36-Item Short Form Health Survey. Although articular OMT was not associated with improvements in the PCS score, it was associated with improvements in the MCS score. Six studies [50, 51, 53, 55, 56, 59] explicitly provided a statement about adverse events, out of which adverse events occurred in the patients of three studies [51, 53, 55]. Kendall et al. [55] reported the following mild adverse events in both study groups: increased neck pain (OMT=2, control=1), headaches (OMT=1, control=1), and midback pain (OMT=1, control=0). DiFrancisco-Donoghue et al. [51] reported that 1 participant did not feel well after OMT, and Fraix et al. [53] reported a fall that was not associated with OMT. DiFrancisco-Donoghue et al. [51] also reported 1 dropout in the OMT group due to an adverse event, and Papa et al. [56] reported that 7 participants from the control group dropped out due to inefficacy.

Discussion

The current review evaluated the existing literature to determine the quality of evidence from pooled estimates of the effect of OMT and OMT analogous techniques on the treatment of dizziness caused by neuro-otologic disorders. Overall, our results indicated that OMT and analogous techniques can be utilized as a practical treatment approach to manage dizziness caused by neuro-otological disorders. Moderate-quality evidence showed that articular OMT techniques effectively reduced disability associated with dizziness, dizziness severity, and dizziness frequency. The studies that could not be pooled utilized a variety of OMT technique types or a control comparator to investigate the impact of OMT techniques on these three outcomes. The pooled analysis for ACD rates showed a nonsignificant association with OMT techniques. Unfortunately, we were unable to find enough studies to pool data for other outcomes, such as the risk of falls and QOL. None of the included studies reported the effect of OMT on the RTW outcome. However, data for unpooled outcomes showed improvements in the MCS score, but not the PCS score, when assessing QOL, and 1 of the 3 studies assessing the risk of falls showed a significant reduction in that outcome with OMT. Similarly, pooling was not possible for the harm outcomes of dropout rates due to inefficacy and adverse events.

To our knowledge, the current review is the first systematic review and meta-analysis that reports pooled estimates of the impact of OMT and analogous techniques on outcomes for the treatment of dizziness caused by neuro-otologic disorders. Previously, a systematic review by Veloso et al. [23] investigated the effect of OMT on postural balance. Veloso et al. [23] included studies that enrolled healthy patients and patients with musculoskeletal conditions. However, Veloso et al. [23] did not perform a quality assessment, such as ROB. A systematic review by Tramontano et al. [60] included five RCTs and observational studies with restricted comparators, such as no treatment, placebo/sham, standard/routine care, or wait-list control, to evaluate the impact of OMT techniques on vertigo and balance disorders. Further, they assessed ROB with the Newcastle-Ottawa Scale, which is suitable for observational studies but should not be utilized for RCTs [60]. One of the limitations of that review [60] was heterogeneity in the outcomes data and measurement scales.

Because of these limitations in existing reviews, there was a need for a high-quality systematic review with pooled estimates that evaluated the effectiveness of OMT for treating dizziness caused by neuro-otologic disorders. As such, our review utilized rigorous methods and transparent data reporting, which allows for a more precise interpretation of results. In addition, we did not restrict eligibility criteria to any specific OMT technique or comparator. We also adjudicated the assessed OMT and analogous techniques according to similarities between OMT technique types. As a result of adjudication and data pooling based on similarities between technique types, heterogeneity in our meta-analyses was low. When necessary, we converted outcomes data from reviewed studies to the most frequently utilized scale, which provided better interpretability. We also determined the quality of the evidence in the pooled analyses utilizing the GRADE approach.

Our meta-analysis showed moderate-quality evidence that OMT and analogous techniques effectively reduced disability associated with dizziness, dizziness severity, and dizziness frequency. These improved outcomes will likely also do the following: improve QOL [61]; decrease psychological stress, medication use, and mobility restriction; and reduce perceptions of dizziness and disability. In one of the reviewed studies, data for the unpooled QOL outcome showed that articular OMT improved the MCS score but not the PCS score on the 36-Item Short-Form Health Survey. A possible explanation for this finding may be that dizziness, as a symptom, has more impact on physical function. Therefore, improvement in the PCS was not significant when compared with the MCS. Similar findings related to improvements in MCS but not in PCS were reported in orthopedic patients [62, 63]. From an osteopathic perspective, these findings may relate to the mind, body, spirit connection as well as the biomechanical interconnectedness of the whole body. Manual treatments may improve well-being by improving symptoms. However, to improve physical scores, dysfunctions outside of the head and neck, that may be affecting balance, may require treatment to improve physical scores. Future studies assessing the impact of whole-body treatments on QOL are needed to better understand these findings.

In addition to effectiveness outcomes, the current review also assessed harm outcomes, such as ACD rates and dropouts due to inefficacy and adverse events. While a few minor adverse events, such as neck pain and headache, were reported in participants that received OMT, only one participant dropped out due to an adverse event. No significant associations were seen between the use of OMT and ACD. Most systematic reviews and meta-analyses focus on the beneficial results of an intervention, with little to no emphasis on tolerability outcomes [27, 64, 65]. For any intervention, especially those utilized in osteopathic clinical practice, the treatment philosophy is based on safety, equitability, effectiveness, and patient centeredness [66–68]. Because OMT is increasingly utilized as a safe and effective treatment method, it is imperative to understand its benefits and potential harmful effects. Therefore, understanding the risks of treatment through reported ACD rates and dropouts due to adverse events will allow clinicians to create a safe practice environment in which patients can establish realistic expectations, give adequate consent, and make an informed choice about available interventions.

Although none of the reviewed studies investigated the impact of OMT on RTW, our results suggest indirect information about RTW. In an observational study by Hou et al. [69], patients with mental stress and poor QOL had a low probability of RTW. Based on our finding that suggested an improvement in QOL as measured by the MCS, we can speculate that OMT may increase the probability of RTW [69–71].

The current review had several limitations. None of the reviewed studies met all ROB criteria. Most had high ROB and were downrated for bias components, such as random sequence generation and lack of blinding. However, this limitation was expected because it is difficult in procedure-based RCTs to blind patients and practitioners. Another limitation was that the reviewed studies lacked power, and only three accounted for missing data [50, 57, 58]. Small sample sizes and high dropout rates increased the risk of error in our results from overestimating or underestimating the effect [72, 73]. Another limitation was that the specific neuro-otologic etiology of dizziness varied in the reviewed studies: some studies excluded etiologies that others included. For example, the term "cervicogenic dizziness" has multiple definitions in the literature. Some studies [40, 50, 54, 55, 57, 58] utilized the term to describe a proprioceptive-vestibular mismatch associated with neck pain. Many of the OMT protocols involved various types of techniques, so we were unable to pool data by a specific technique. However, articulator OMT techniques were utilized as the primary approach in some studies, which allowed for pooled analyses. Because studies assessed the impact of manual techniques on symptoms rather than on a comprehensive treatment approach, we were able to include OMT analogous techniques in our meta-analysis. However, different manual medicine disciplines may apply similar techniques differently, which may affect the generalizability of our findings. A final limitation is related to the nature of the current evidence: specifically, we were unable to compare the effectiveness of OMT and OMT analogous techniques with other common interventions utilized to manage dizziness, such as medical interventions or vestibular rehabilitation, in a pooled analysis.

Conclusions

To our knowledge, the current systematic review and meta-analysis is the most methodologically rigorous review performed to date that investigates the effectiveness of OMT and OMT analogous techniques for the treatment of dizziness caused by neuro-otologic disorders. Our findings suggested that OMT effectively reduced disability associated with dizziness, dizziness severity, and dizziness frequency. Our review also suggested that OMT was well tolerated by patients; however, data related to dropout rates due to inefficacy and adverse events were rarely reported. In the future, high-quality RCTs with larger sample sizes should be conducted to better delineate the effectiveness of OMT and analogous techniques for the treatment of dizziness.

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References

1. Bisdorff A, Bosser G, Gueguen R, Perrin P. The epidemiology of vertigo, dizziness, and unsteadiness and its links to co-morbidities. Front Neurol 2013;4:29.
2. Post RE, Dickerson LM. Dizziness: a diagnostic approach. Am Fam Physician 2010;82:361–8.
3. von Brevern M, Radtke A, Lezius F, Lempert T, Neuhauser H. Epidemiology of benign paroxysmal positional vertigo: a population based study. J Neurol Neurosurg Psychiatry 2007;78:710–5.
4. Lee R, Elder A. Dizziness in older adults. Medicine 2013;41:16–9.
5. Yardley L, Burgneay J, Nazareth I, Luxon L. Neuro-otological and psychiatric abnormalities in a community sample of people with dizziness: a blind, controlled investigation. J Neurol Neurosurg Psychiatry 1998;65:679–84.
6. Maarsingh OR, Dros J, Schellevis FG, van Weert HC, Bindels PJ, van der Horst HE. Dizziness reported by elderly patients in family practice: prevalence, incidence, and clinical characteristics. BMC Fam Pract 2010;11:2.
7. Kruschinski C, Sheehy O, Hummers-Pradier E, Lelorier J. Fracture risk of patients suffering from dizziness: a retrospective cohort study. Eur J Gen Pract 2010;16:229–35.
8. Rubenstein LZ, Josephson KR. Falls and their prevention in elderly people: what does the evidence show? Med Clin 2006;90:807–24.
9. de Moraes SA, de Souza Soares WJ, Ferriolli E, Perracini MR. Prevalence and correlates of dizziness in community-dwelling older people: a cross sectional population based study. BMC Geriatr 2013;13:4.
10. Dros J, Maarsingh OR, Beem L, van der Horst HE, ter Riet G, Schellevis FG, et al. Impact of dizziness on everyday life in older primary care patients: a cross-sectional study. Health Qual Life Outcome 2011;9:44.
11. Johansson M, Andersson G. Prevalence of dizziness in relation to psychological factors and general health in older adults. Audiol Med 2006;4:144–50.
12. Stevens KN, Lang IA, Guralnik JM, Melzer D. Epidemiology of balance and dizziness in a national population: findings from the English Longitudinal Study of Ageing. Age Ageing 2008;37:300–5.
13. Campbell AJ, Borrie MJ, Spears GF, Jackson SL, Brown JS, Fitzgerald JL. Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. Age Ageing 1990;19:136–41.
14. Skoien AK, Wilhemsen K, Gjesdal S. Occupational disability caused by dizziness and vertigo: a register-based prospective study. Br J Gen Pract 2008;58:619–23.
15. Saber Tehrani AS, Coughlan D, Hsieh YH, Mantokoudis G, Korley FK, Kerber KA, et al. Rising annual costs of dizziness presentations to U.S. emergency departments. Acad Emerg Med 2013;20:689–96.
16. Sibley KM, Voth J, Munce SE, Straus SE, Jaglal SB. Chronic disease and falls in community-dwelling Canadians over 65 years old: a population-based study exploring associations with number and pattern of chronic conditions. BMC Geriatr 2014;14:22.
17. Wu SS, Hostoffer RW, Gibbons K, Shaw HH, Shaw MB. Osteopathic considerations in patients with head, eyes, ears, nose, and throat disorders. In: Seffinger DA, editor. Foundations of osteopathic medicine: philosophy, science, clinical applications, and research, 4th ed. Philadelphia, PA: Wolters Kluwer; 2018:1386–416 pp.
18. Seffinger MA, editor. Foundations of osteopathic medicine: philosophy, science, clinical applications, and research, 4th ed. Philadelphia, PA: Wolters Kluwer; 2018.
19. Fraix M. Osteopathic manipulative treatment and vertigo: a pilot study. PM R 2010;2:612–8.
20. Fraix M, Gordon A, Graham V, Hurwitz E, Seffinger MA. Use of the SMART Balance Master to quantify the effects of osteopathic manipulative treatment in patients with dizziness. J Am Osteopath Assoc 2013;113:394–403.

21. Buscemi A, Cannatella M, Lutrario P, Rapisarda A, Gregorio GD, Coco M. Effects of osteopathic treatment on postural equilibrium evaluated through a stabilometric platform: a randomized and controlled study. J Funct Morphol Kinesiol 2017;2:18.
22. Haidich AB. Meta-analysis in medical research. Hippokratia 2010;14:29–37.
23. Veloso CF, da Silveira AF, Garcia MV, Romero CAP. Osteopathic manipulation treatment on postural balance: a systematic review. Man Ther Posturol Rehabil J 2016;14:352.
24. Rehman Y, Kirsch J, Bhatia S, Johnston R, Bingham J, Senger B, et al. Impact of osteopathic manipulative techniques on the management of dizziness caused by neuro-otologic disorders: protocol for systematic review and meta-analysis. Int J Osteopath Med 2021;42:76–82.
25. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
26. Zorzela L, Loke YK, Ioannidis JP, Golder S, Santaguida P, Altman DG. PRISMA harms checklist: improving harms reporting in systematic reviews. BMJ 2016;352:i157.
27. Zorzela L, Golder S, Liu Y, Pilkington K, Hartling L, Joffe A, et al. Quality of reporting in systematic reviews of adverse events: systematic review. BMJ 2014;348:f7668.
28. Higgins JPT, Thomas J, Chandler J, Cumpston M, Tianjing L, Page M, editors, et al. Cochrane handbook for systematic reviews of interventions, 2nd ed. Chichester, UK: John Wiley & Sons; 2019.
29. Cochrane effective practice and organisation of care (EPOC). Available from: http://epoc.cochrane.org/epoc-specific-resources-review-authors [Accessed 12 Oct 2020].
30. Giusti R, editor. Glossary of osteopathic terminology, 3rd ed. Chevy Chase, MD: American Association of Colleges of Osteopathic Medicine; 2017.
31. Atchison J, Tolchin RB, Ross BS, Eubanks JE. Manipulation, traction, and massage. In: Cifu DX, editor. Braddom's physical medicine and rehabilitation, 6th ed. Elsevier; 2021:316–37.e7 pp.
32. Chiaramonte D, D'Adamo C, Morrison B. Integrative approaches to pain management. In: Benson HT, Rathmell JP, Wu CL, Turk DC, Argoff CE, Hurley RW, editors. Practical management of pain, 5th ed. Elsevier; 2014:658–68.e3 pp.
33. Franke H, Franke JD, Fryer G. Osteopathic manipulative treatment for chronic nonspecific neck pain: a systematic review and meta-analysis. Int J Osteopath Med 2015;18:255–67.
34. Franke H, Franke JD, Fryer G. Osteopathic manipulative treatment for nonspecific low back pain: a systematic review and meta-analysis. BMC Muscoskel Disord 2014;15:286.
35. Licciardone JC. Systematic review and meta-analysis conclusions relating to osteopathic manipulative treatment for low back pain remain valid and well accepted. J Bodyw Mov Ther 2013;17:2–4.
36. Rehman Y, Ferguson H, Bozek A, Blair J, Allison A, Johnston R. Dropout associated with osteopathic manual treatment for chronic noncancerous pain in randomized controlled trials. J Osteopath Med. 2021;121:417–28.
37. Rehman Y, Ferguson H, Bozek A, Blair J, Allison A, Johnston R. Osteopathic manual treatment for pain severity, functional improvement, and return to work in patients with chronic pain. J Am Osteopath Assoc. 2020;120:888–906.
38. Luo D, Wan X, Liu J, Tong T. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Stat Methods Med Res 2018;27:1785–805.
39. Shi J, Luo D, Weng H, Zeng XT, Lin L, Chu H, et al. Optimally estimating the sample standard deviation from the five-number summary. 10.1002/jrsm.1429. Res Synth Methods 2020;11: 641–54.
40. Karlberg M, Magnusson M, Malmstrom EM, Melander A, Moritz U. Postural and symptomatic improvement after physiotherapy in patients with dizziness of suspected cervical origin. Arch Phys Med Rehabil 1996;77:874–82.
41. Balduzzi S, Rücker G, Schwarzer G. How to perform a meta-analysis with R: a practical tutorial. Evid Base Ment Health 2019; 22:153–60.
42. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336: 924–6.
43. Guyatt GH, Oxman AD, Kunz R, Vist G, Falck-Ytter Y, Schünemann HJ, et al. What is "quality of evidence" and why is it important to clinicians? BMJ 2008;336:995–8.
44. Higgins JPT, Altman DG, Gøtzsche PC, Juni P, Moher D, Oxman A, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5928.
45. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019;366:l4898.
46. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman N, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016;355: i4919.
47. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557–60.
48. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med 2002;21:1539–58.
49. Atay F, Bayramlar K, Sarac ET. Effects of craniosacral osteopathy in patients with peripheral vestibular pathology. ORL J Otorhinolaryngol Relat Spec 2021;83:7–13.
50. Carrasco-Uribarren A, Rodriguez-Sanz J, Lopez-de-Celis C, Perez-Guillen S, Tricas-Moreno JM, Cabanillas-Barea S. Short-term effects of the traction-manipulation protocol in dizziness intensity and disability in cervicogenic dizziness: a randomized controlled trial. Disabil Rehabil 2022;44:3601–9.
51. Francisco-Donoghue JD, Apoznanski T, de Vries K, Jung MK, Mancini J, Yao S. Osteopathic manipulation as a complementary approach to Parkinson's disease: a controlled pilot study. NeuroRehabilitation 2017;40:145–51.
52. do Nascimento Oliveira OA, de Andrade Mesquita LS, Mendes MR, de Oliveira LMM, Almeida LCC. Effects of cranial osteopathic techniques in the symptoms of benign positional paroxistic vertical. Man Ther Posturol Rehabil J 2020;18:1–5.
53. Fraix M, Badran S, Graham V, Redman-Bentley D, Hurwitz EL, Quan VL, et al. Osteopathic manipulative treatment in individuals with vertigo and somatic dysfunction: a randomized, controlled, comparative feasibility study. J Osteopath Med 2021;121:71–83.
54. Heikkilä H, Johansson M, Wenngren BI. Effects of acupuncture, cervical manipulation and NSAID therapy on dizziness and

impaired head repositioning of suspected cervical origin: a pilot study. Man Ther 2000;5:151–7.
55. Kendall JC, French SD, Hartvigsen J, Azari MF. Chiropractic treatment including instrument-assisted manipulation for non-specific dizziness and neck pain in community-dwelling older people: a feasibility randomised sham-controlled trial. Chiropr Man Ther 2018;26:14.
56. Papa L, Amodio A, Biffi F, Mandara A. Impact of osteopathic therapy on proprioceptive balance and quality of life in patients with dizziness. J Bodyw Mov Ther 2017;21:866–72.
57. Reid SA, Callister R, Snodgrass SJ, Katekar MG, Rivett DA. Manual therapy for cervicogenic dizziness: long-term outcomes of a randomised trial. Man Ther 2015;20:148–56.
58. Reid SA, Rivett DA, Katekar MG, Callister R. Sustained natural apophyseal glides (SNAGs) are an effective treatment for cervicogenic dizziness. Man Ther 2008;13:357–66.
59. Sun YX, Wang Y, Ji X, Wu X, Zhao Y, Ding Y, et al. A randomized trial of Chinese Diaoshi Jifa on treatment of dizziness in meniere's disease. Evid Based Complement Alternat Med 2014;2014: 521475.
60. Tramontano M, Consorti G, Morone G, Lunghi C. Vertigo and balance disorders. The role of osteopathic manipulative treatment: a systematic review (Schwindel und Gleichgewichtsstörungen – Rolle der osteopathischen Manipulationstherapie: Eine systematische Übersichtsarbeit). Complement Med Res 2021;28:368–77.
61. Jung FC, Mathew S, Littmann AE, Donald CWM. Clinical decision making in the management of patients with cervicogenic dizziness: a case series. J Orthop Sports Phys Ther 2017;47:874–84.
62. Nortvedt MW, Riise T, Myhr KM, Nyland HI. Performance of the SF-36, SF-12, and RAND-36 summary scales in a multiple sclerosis population. Med Care 2000;38:1022–8.
63. Laucis NC, Hays RD, Bhattacharyya T. Scoring the SF-36 in orthopaedics: a brief guide. J Bone Jt Surg Am 2015;97:1628–34.
64. McIntosh HM, Woolacott NF, Bagnall AM. Assessing harmful effects in systematic reviews. BMC Med Res Methodol 2004;4. https://doi.org/10.1186/1471-2288-4-19.
65. Ernst E, Pittler MH. Assessment of therapeutic safety in systematic reviews: literature review. BMJ 2001;323:546.
66. Mitchell PH. Defining patient safety and quality care. In: Hughes RG, editor. Patient safety and quality: an evidence-based Handbook for nurses. Agency for Healthcare Research and Quality; 2008.
67. Steel A, Blaich R, Sundberg T, Adams J. The role of osteopathy in clinical care: broadening the evidence-base. Int J Osteopath Med 2017;24:32–6.
68. Carnes D. What can osteopaths learn from concerns and complaints raised against them? A review of insurance and regulator reports. Int J Osteopath Med 2016;22:3–10.
69. Hou WH, Sheu CF, Liang HW, Hsieh CL, Lee Y, Chuang HY, et al. Trajectories and predictors of return to work after traumatic limb injury: a 2-year follow-up study. Scand J Work Environ Health 2012;38:456–66.
70. Lötters F, Hogg-Johnson S, Burdorf A. Health status, its perceptions, and effect on return to work and recurrent sick leave. Spine 2005;30:1086–92.
71. Weerdesteijn KHN, Schaafsma F, Bonefaas-Groenewoud K, Heymans M, Van der Beek A, Anema J. Predicting return to work after long-term sickness absence with subjective health complaints: a prospective cohort study. BMC Publ Health 2020;20:1095.
72. Faber J, Fonseca LM. How sample size influences research outcomes. Dental Press J Orthod 2014;19:27–9.
73. McNeish D, Stapleton L. The effect of small sample size on two-level model estimates: a review and illustration. Educ Psychol Rev 2016;28:295–314.

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