Effectiveness of manual therapy in the treatment of cervicogenic headache: A systematic review

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Abstract
Objective: The aim of this study was to identify the manual therapy (MT) methods and techniques that have been evaluated for the treatment of cervicogenic headache (CH) and their effectiveness.

Background: MT seems to be one of the options with the greatest potential for the treatment of CH, but the techniques to be applied are varied and there is no consensus on which are the most indicated.

Methods: A systematic search in Scopus, Medline, PubMed, Cinahl, PEDro, and Web of Science with the terms: secondary headache disorders, physical therapy modalities, musculoskeletal manipulations, cervicogenic headache, manual therapy, and physical therapy. We included articles published from 2015 to the present that studied interventions with MT techniques in patients with CH. Two reviewers independently screened 365 articles for demographic information, characteristics of study design, study-specific intervention, and results. The Oxford 2011 Levels of Evidence and the Jadad scale were used.

Results: Of a total of 14 articles selected, 11 were randomized control trials and three were quasi-experimental studies. The techniques studied were: spinal manipulative therapy, Mulligan’s Sustained Natural Apophyseal Glides, muscle techniques, and translatory vertebral mobilization. In the short-term, the Jones technique on the trapezius and ischemic compression on the sternocleidomastoid achieved immediate improvements, whereas adding spinal manipulative therapy to the treatment can maintain long-term results.

Conclusions: The manual therapy techniques could be effective in the treatment of patients with CH. The combined use of MT techniques improved the results compared with using them separately. This review has methodological limitations, such as the inclusion of quasi-experimental studies and studies with small sample sizes that reduced the generalizability of the results obtained.

Abbreviations: CCF, cranio-cervical flexion; CH, cervicogenic headache; CHISG, Cervicogenic Headache International Study Group; MeSH, Medical Subject Headings; MT, manual therapy; PICOS, population, intervention, comparison, outcome, and study design; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; ROM, range of motion; SMT, spinal manipulative therapy; SNAG, sustained natural apophyseal glides.

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INTRODUCTION

Cervicogenic headache (CH) is a secondary headache caused by a disorder of the cervical spine and its disc or bony and/or periaricular components and is often accompanied by neck pain. The diagnostic criteria for CH are: (1) clinical and/or imaging evidence of a disorder or lesion within the cervical spine or soft tissues of the neck, which is known to cause headache; and (2) evidence of causation demonstrated by at least two of the following: headache has developed in temporal relation to the onset of the cervical disorder or appearance of the lesion, headache has significantly improved or resolved in parallel with improvement in or resolution of the cervical disorder or lesion, cervical range of motion (ROM) is reduced and headache is made significantly worse by provocative maneuvers, and/or headache is abolished following diagnostic blockade of a cervical structure or its nerve supply. Such pain shows a marked topographic achar is abolished following diagnostic blockade of a cervical structure or its nerve supply. Such pain shows a marked topographic achar is abolished following diagnostic blockade of a cervical structure or its nerve supply. Such pain shows a marked topographic a.
publication year), characteristics of the sample (age, sex, inclusion and exclusion criteria, and number of participants), study-specific parameters (study type, duration of the intervention, and MT techniques applied), and results obtained (variables analyzed, instruments used, and time of follow-up). Tables were used to describe both the studies' characteristics and the extracted data. When possible, the results were gathered based on type of intervention applied. The Oxford 2011 Levels of Evidence and the Jadad scale were used to assess the quality of the studies.

**Statistical analysis**

The studies were analyzed in relation to pre- and post-test comparisons of each intervention group. In addition, intergroup comparisons (in those studies that included several sample subgroups) were also considered. Meta-analyses of the included studies were not included owing to variability in the assessment methods of the analyzed variables.

**RESULTS**

Of 446 search results, 365 studies were considered eligible for inclusion after removing duplicates. Among the 365 papers screened, 351 were excluded after abstract and title screening. After the first reading of all candidate full texts, kappa score of reviewers one and two was 0.19, indicating slight agreement. Of the 14 full-text articles assessed for eligibility, all were included in the final synthesis, as depicted by the PRISMA flowchart in Figure 1.

All the data necessary for analysis were obtained from all the studies analyzed. Of the 14 articles, three studied spinal manipulative
therapy (SMT).\textsuperscript{16-18} four studied the efficacy of Mulligan's Sustained Natural Apophyseal Glides (SNAGs),\textsuperscript{19-22} and four evaluated muscle techniques (ischemic compression of trigger points,\textsuperscript{23} stretching,\textsuperscript{24} suboccipital muscle relaxation,\textsuperscript{25} and Jones strain/counterstrain technique, which is a positional release technique\textsuperscript{26}). In addition, one study evaluated translatory vertebral mobilization,\textsuperscript{27} one compared the self-acupressure pillow with a combination of MT techniques,\textsuperscript{28} and another study compared the efficacy of personalized versus non-personalized treatment with MT.\textsuperscript{29}

Regarding the experimental designs of the investigations analyzed, 11 studies were randomized controlled trials,\textsuperscript{16,17,19,20,23-29} and the remaining three were quasi-experimental studies (a multi-center randomized clinical trial\textsuperscript{18} and 2 experimental noncontrolled studies\textsuperscript{21,22}).

The methodological quality of the studies was three points or more on the Jadad scale in 42.9\% of the studies\textsuperscript{17-19,27-29} and was not zero in any case. The most common methodological shortcoming was the lack of information of withdrawals\textsuperscript{21,23-25,26} and the absence of blinding.\textsuperscript{16,19-22,24,25,27-29} At the same time, as can be seen in Table 2, the level of evidence provided was between I (78.6\%)\textsuperscript{16,17,19,20,23-29} and II (21.4\%).\textsuperscript{18,21,22}

The SMT is thought to act on a manipulatable lesion (often called a functional spinal lesion or subluxation) that itself is conformable to specific forces and moments in such a way that the internal mechanical stresses that generate symptoms are reduced.\textsuperscript{30} Research examining the effects of SMT showed significant improvements in headache frequency after 18 sessions (maximum) of manual, high-speed, low-amplitude manipulation of the cervical and upper thoracic regions at the sites of joint dysfunction (joint restriction or pain)\textsuperscript{16-18} and also after 12 sessions of placebo SMT (nonspecific sham manipulation at low speed and low amplitude).\textsuperscript{17} However, this placebo treatment failed to improve either the intensity or duration of CH, whereas the SMT treatment did.\textsuperscript{17} Notably, Haas et al.\textsuperscript{16} found that improvements in the frequency and intensity of CH were achieved after 6 weeks of treatment three times a week and remained for up to 1 year after treatment. Pain intensity and perceived disability improved significantly more with SMT than with massage\textsuperscript{16} or with treatment with Maitland mobilization therapy and cranio-cervical flexion (CCF) exercises with a pressure sensor placed under the neck.\textsuperscript{18} In contrast, the number of days on medication and quality of life were unchanged in one case\textsuperscript{16} but SMT at the C1-C2 and T1-T2 joints bilaterally did achieve a significant reduction in days on medication compared with Maitland techniques and CCF exercises.\textsuperscript{18}

In relation to treatment with SMT, it should be noted that one of the studies identified no adverse effects of any type,\textsuperscript{18} whereas, in another study, the adverse events were mild and transient (tenderness and fatigue in the SMT group and also in the placebo group).\textsuperscript{17} In the third case, 40\% of the patients who received SMT and 20\% of those treated with light massage reported adverse events after treatment (neck pain or stiffness, upper extremity pain or tingling, increased intensity of headache, nausea, or dizziness), all of which were short-term and transient.

Studies evaluating the efficacy of Mulligan's SNAGs (consisting of facilitating physiologically correct movement while bearing weight) obtained significant improvements in pain intensity and perceived disability.\textsuperscript{19-22} However, Veena et al.\textsuperscript{19} identified that

\begin{center}
FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram
\end{center}
### TABLE 2: Methodological characteristics of the studies analyzed

| Authors                          | Design | Sample size (women), N | Inclusion criteria                                                                 | Exclusion criteria                                                                                                                                                                                                 | Jadad scale |
|----------------------------------|--------|------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Chaibi et al. (2017)\(^{17}\)    | RCT    | 12 (8)                 | Age between 18 and 70 years. Diagnosis of CH with at least 3 main CHISG criteria    | Presence of contraindications for the application of spinal manipulative techniques, pregnancy, depression, and/or radiculopathy. History of treatment with spinal manipulative techniques in the previous month                        | 2 2 1 5 I   |
| Christian et al. (2017)\(^{20}\) | RCT    | 23 (11)                | Age between 25 and 35 years. Diagnosis of CH according to International Headache Society criteria. Positive Flexion-Rotation test results. Reduced cervical range of motion | Presence of dizziness and/or symptoms of visual disturbances, primary headaches, congenital disturbances, inflammatory and/or infectious disturbances in the cervical spine, vertebra-basilar insufficiency, and/or cervical hypermobility. Consumption of steroids and/or analgesics | 1 0 1 2 I   |
| Dunning et al. (2016)\(^{18}\)   | MRCT   | 110 (74)               | Age between 18 and 65 years. Diagnosis of CH according to Cervicogenic Headache International Study Group criteria. At least seminal frequency of CH for at least 3 months. Minimum pain intensity of 2 points on the Numerical Rating Scale. Score of at least 10 points on the Neck Disability Index | Presence of primary headaches, bilateral headaches, and/or neurological signs. Diagnosis of cervical spinal stenosis. History of whiplash in the previous 6 weeks, cranio-cervical surgery, and/or physiotherapy treatment in the previous 3 months | 2 1 1 4 II  |
| Fereira and Satralkar (2017)\(^{26}\) | RCT    | 30 (not described)     | Age between 20 and 65 years. Diagnosis of CH. Presence of myofascial trigger points in upper trapezius. Occipital nerve neurodynamic test with positive findings. Positive Flexion-Rotation Test results (reduction of more than 30°). Drug use | Diagnosis of disc pathology, rheumatoid arthritis, ankylosing spondylitis, and/or primary muscle diseases. Presence of primary headaches, migraine and/or tension-type headaches, and/or infectious conditions causing headache. History of tumor and/or cervical surgery | 1 0 0 1 I   |
| Haas et al. (2018)\(^{16}\)      | RCT    | 256 (182)              | Age older than 18 years. Diagnosis of CH according to diagnostic criteria of the International Headache Society. Minimum average pain intensity of 3 points on the Visual Analog Scale. Presence of restricted cervical movement | Presence of contraindications for the application of spinal manipulative techniques and/or pregnancy. History of treatment with physiotherapy in the previous 3 months or with drugs in the previous month, brain or spine surgery, cancer, spinal pathology, inflammatory arthropathy, anticoagulant conditions, autoimmune disorders, and/or neurodegenerative diseases | 1 0 1 2 I   |

(Continues)
| Authors                  | Design | Sample size (women), N | Inclusion criteria                                                                 | Exclusion criteria                                                                                                                                                                                                 | Jadad scale |
|-------------------------|--------|------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Jafari et al. (2017)    | RCT    | 19 (not described)     | Diagnosis of CH according to the International Headache Society, Presence of myofascial trigger points in sternocleidomastoid                | Presence of other types of headaches, more than 1 active myofascial trigger point in the sternocleidomastoid, rheumatic diseases, phasic, and/or psychiatric limitations. History of treatment with physiotherapy during the previous year and/or neck or shoulder surgery                                    | 1 1 0 2 I   |
| Malo-Urriés et al. (2017) | RCT    | 82 (62)                | Age older than 18 years. Diagnosis of CH according to the CHISG                        | History of treatment of CH during the previous month. Presence of neurological signs and/or contraindications for manual therapy                                                                                       | 2 0 1 3 I   |
| Mohamed et al. (2019)   | ENCS   | 48 (20)                | Presence of headaches for at least 3 months, unilateral neck pain and stiffness, limited range of motion of more than 10 degrees in the Flexion-Rotation Test, and dizziness caused by headaches and/or cervical extension | Presence of primary headaches, congenital spinal conditions, herniated discs, and/or fractures; contraindications for mobilization techniques; vertebra-basilar insufficiency; and/or vestibular dysfunction                                  | 1 0 0 1 II  |
| Park et al. (2017)      | RCT    | 30 (9)                 | Diagnosis of CH according to International Headache Society criteria. Presence of CH for a minimum of 4 months and a maximum of 2 years | Not described                                                                                                                                                                                                     | 1 0 0 1 I   |
| Patra et al. (2018)     | ENCS   | 114 (77)               | Age between 20 and 50 years. Diagnosis of CH according to the main International Headache Society criteria | History of surgery and/or cervical trauma, vertebral neoplasm. Presence of congenital spinal deformity, cervical radiculopathy, dizziness, vertebra-basilar insufficiency, bone infection, fracture. Consumption of anti-inflammatory or muscle relaxants | 1 0 1 2 II  |
| Svedmark et al. (2016)  | RCT    | 120 (120)              | Presence of cervico-brachial pain for at least 6 weeks. Neck Disability Index score between 10 and 68. Impairment of work productivity owing to pain | History of trauma, cancer, surgery, and/or spinal fracture. Diagnosis of cervical radiculopathy, vestibular dysfunction, type 1 diabetes, rheumatic disease, anxiety, depression. Presence of concurrent low back pain, temporomandibular disorders, severely restricted range of motion and/or cervical flexion, catastrophic thoughts, low expectations for physical therapy treatment | 2 0 1 3 I   |
| Veena et al. (2018)     | RCT    | 30 (24)                | Diagnosis of CH                                                                       | Not described                                                                                                                                                                                                     | 2 0 1 3 I   |
such improvements were statistically superior with the application of Muscle Energy Techniques of the suboccipital muscles. However, Christian\textsuperscript{20} found that cervical ROM improved more with Mulligan's SNAGs than with the application of Maitland's anterior-posterior glides (both techniques were applied on C2). Comparison of this technique with dry needling of the suboccipital, paraspinal, and trapezius muscles revealed that Mulligan's SNAGs did not result in improvement of painful pressure thresholds in the C5-C6 paraspinous and trapezius muscles and that the improvements achieved were significantly greater if both interventions were combined.\textsuperscript{22} Mohamed et al.\textsuperscript{21} analyzed the effectiveness of different applications of SNAGs: at C2, at C1-C2 in rotation, and the combination of both. They obtained significant improvements in all the variables analyzed (pain intensity, quality of life, perceived disability, and ROM) but the quality of life in the SNAGs group in C1-C2 obtained a significantly greater improvement than the application at C2 and the combination of both techniques. However, the group that received both techniques obtained a significantly greater improvement in pain intensity, perceived disability, and ROM (Table 3).

The randomized clinical trials evaluating muscle MT techniques identified significant improvements in pain intensity and frequency, perceived disability, and cervical ROM with both the application of the Jones technique on the trapezius and neural mobilization therapy of the occipital nerve.\textsuperscript{26} In the Jones technique for the trapezius, the physical therapist applies pressure on the tender point and flexes the patient's head laterally to the side of the tender point, followed by a shoulder abduction of approximately 90 degrees. The physical therapist holds this position for 90 s and then passively returns the patient to the initial position. This should be repeated three times in each session.\textsuperscript{31} The Jones technique on the trapezius muscle achieved results statistically superior than the neural mobilization therapy of the occipital nerve.

In parallel, ischemic compression is one of the techniques frequently used in the management of myofascial trigger points, which means applying pressure to myofascial trigger points up to the maximum tolerable level.\textsuperscript{32} Ischemic compression of the trigger points of the sternocleidomastoid muscles also significantly reduced the intensity, frequency, and duration of patients' CH.\textsuperscript{23} The area of the trigger points decreased and their painful threshold to pressure increased significantly. However, the authors found no association between these variables and the intensity, frequency, and duration of CH.\textsuperscript{23} Park et al.\textsuperscript{24} applied trapezius muscle stretching and CCF exercises and concluded that muscle tone and cervical stiffness improved. However, the cranio-cervical angle to postural analysis improved significantly more with the application of MT. Yang and Da\textsuperscript{25} evaluated the relaxation of the suboccipital musculature compared with performing active CCF exercises and obtained statistically superior improvements with active intervention in pain intensity and trapezius muscle fatigue. For the application of suboccipital relaxation, the therapist should be positioned cranial to the subject’s head, place fingertips under the subject’s subocciput, and rest the subject’s occiput on the palms of the hands for 20 min, releasing the subocciput.\textsuperscript{23}
| Authors                  | Intervention                                                                 | Time of intervention (no. of sessions) | Follow-up | Within group improvements statistically identified with manual therapy interventions                                                                 |
|-------------------------|-------------------------------------------------------------------------------|----------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chaibi et al. (2017)17  | Group 1: SMT                                                                  | 13 weeks (12)                          | 12 months | Reduction of Headache Index and headache frequency                                                                                                    |
|                         | Group 2: Placebo SMT                                                          |                                        |           |                                                                                                                                                      |
| Christian et al. (2017)20| Group 1: Active exercise and Mulligan’s SNAGs                                | 1 week (6)                             | None      | In the 2 groups: Increased range of motion. Reduction of Neck Disability Index and of the headaches’ frequency and intensity                           |
|                         | Group 2: Active exercise and MMT                                              |                                        |           |                                                                                                                                                      |
| Dunning et al. (2016)18 | Group 1: SMT                                                                  | 4 weeks (6-8)                          | 3 months  | In the 2 groups: Reduction in headache intensity, frequency, duration, Neck Disability Index, and medication intake. Increased self-perceived improvement |
|                         | Group 2: Cranio-cervical flexion exercises and MMT                            |                                        |           |                                                                                                                                                      |
| Fereira and Sattralkar (2017)26| Group 1: Active exercises and SMT                                             | 2 weeks (4-10)                         | None      | In the 2 groups: Increased cervical range of motion. Reduction of Neck Disability Index and pain intensity                                             |
|                         | Group 2: Active exercises and Jones technique                                 |                                        |           |                                                                                                                                                      |
| Haas et al. (2018)16    | Group 1: 6 sessions of SMT                                                    | 6 weeks (6-18)                         | 12 months | In the 4 groups: Reduced frequency, intensity of headaches and Neck Disability Index. In the 12- and 18-sessions groups: Increased self-perceived improvement. |
|                         | Group 2: 12 sessions of SMT                                                   |                                        |           |                                                                                                                                                      |
|                         | Group 3: 18 sessions of SMT                                                   |                                        |           |                                                                                                                                                      |
|                         | Group 4: Massage                                                              |                                        |           |                                                                                                                                                      |
| Jafari et al. (2017)23  | Ischemic compression                                                          | 1 week (4)                             | 2 weeks   | Increased pain threshold to pressure. Reduced intensity, frequency, duration of headaches, and myofascial trigger point area                         |
| Malo-Urriés et al. (2017)27| Vertebral translatory mobilization                                           | 1 day (1)                              | None      | Increased range of motion in extension, rotations, lateral tilt, and total cervical range of motion. Reduction of headache intensity                   |
| Mohamed et al. (2019)21 | Group 1: C2 Mulligan’s SNAGs                                                   | 4 weeks (12)                           | None      | In the 3 groups: Increased quality of life and cervical range of motion. Reduction of Neck Disability Index                                          |
|                         | Group 2: C1-C2 rotation Mulligan’s SNAGs                                      |                                        |           |                                                                                                                                                      |
|                         | Group 3: C2 and C1-C2 rotation Mulligan’s SNAGs                              |                                        |           |                                                                                                                                                      |
| Park et al. (2017)24    | Group 1: Stretching and cranio-cervical flexion exercises                    | 3 weeks (not described)                | None      | In the 2 groups: Reduced tone and stiffness of the suboccipital and upper trapezius muscles                                                           |
|                         | Group 2: Stretching                                                           |                                        |           |                                                                                                                                                      |
| Authors | Intervention | Time of intervention (no. of sessions) | Follow-up | Within group improvements statistically identified with manual therapy interventions |
|---------|-------------|----------------------------------------|-----------|-----------------------------------------------------------------------------------|
| Patra et al. (2018)22 | Group 1: Dry needling Group 2: Mulligan's SNAGs Group 3: Dry needling and Mulligan's SNAGs | 6 weeks (not described) | None | Groups 1 and 3: Increased pain threshold to pressure. In the 3 groups: Reduction of Neck Disability Index |
| Svedmark et al. (2016)29 | Group 1: Personalized manual therapy Group 2: Non-personalized manual therapy Group 3: Free manual therapy treatment | 11 weeks (22-33) | 15 months | In the 3 groups: Increase in self-perceived improvement and pressure pain threshold. Reduction of Neck Disability Index, cervical and headache pain intensity, headache frequency, and pain impact on work |
| Veena et al. (2018)18 | Group 1: Active exercises and Mulligan's SNAGs Group 2: Active exercises and muscle energy techniques | 4 weeks (20) | None | In the 2 groups: Increased cervical extension. Reduction of Neck Disability Index and pain intensity |
| Vernon et al. (2015)28 | SMT, mobilizations, trigger point compression, massage, and self-acupressure pillow SMT, mobilizations, trigger point compression, and massage | 4-5 weeks (6) | None | In the intervention group: Reduction of headache frequency |
| Yang and Da (2017)25 | Group 1: Exercises of cranio-cervical flexion Group 2: Relaxation of the suboccipital musculature | 4 weeks (20) | 1 month | In the 2 groups: Reduction of pain intensity and muscle fatigue |

Note: Dashes indicate not applicable.

Abbreviations: MMT, Maitland mobilization therapy; SMT, spinal manipulative therapy; SNAGs, Mulligan’s sustained natural apophyseal glides.
Translatory vertebral mobilization is defined as a system of manual techniques using straight-line forces delivered in a parallel or perpendicular direction to an individual vertebral joint or motion segment.\textsuperscript{34} Malo-Urriés et al.\textsuperscript{27} evaluated the efficacy of a single session of MT with translatory vertebral mobilization at C1 and identified immediate significant improvements in pain intensity, cervical ROM, and painful threshold to pressure in the trapezius, C2-C3 zygapophyseal joint, and suboccipital muscles.

Comparison of the self-acupressure pillow with a combination of MT techniques, including cervical and upper thoracic SMT, mobilizations, trigger point compression, and massage, revealed statistically superior improvements in the frequency of CH in patients treated with MT.\textsuperscript{28} However, neither intervention resulted in significant changes in pain intensity or perceived disability. Similarly, the comparison between customized and noncustomized MT treatment showed no differences between the two intervention modalities in these two variables or in the frequency of CH.\textsuperscript{29} However, both customized and noncustomized treatments achieved significantly greater improvements than MT treatment based on patient preference. Pain threshold to trapezius pressure was the only variable that improved more with personalized treatment.

**DISCUSSION**

The aim of this work was to identify the MT methods and techniques that are being evaluated for the treatment of CH and, among them, to determine those that have demonstrated the greatest efficacy for this purpose. Considering the results obtained, it can be considered that SMT, Mulligan’s SNAGs, ischemic compression of trigger points, relaxation of the suboccipital musculature, Jones technique, and translatory vertebral mobilization improve the symptoms caused by CH.

When the samples’ ages are computed, the overall mean is 35.8 years. This figure is close to the 33 years of age identified as the mean age of onset of CH.\textsuperscript{34} Some studies established age ranges as inclusion criteria\textsuperscript{17,18,20,22,26} but did not perform different treatments according to this characteristic. In the results analyzed, no relationship was found between the effect of the interventions and the age range of the patients, although two of the studies that applied Mulligan’s SNAGs\textsuperscript{20,22} included younger patients than the rest (younger than 50 years). Cervical osteoarthritis, common in many older patients, may be associated with headache and cervical muscle dysfunction.\textsuperscript{10} This phenomenon may point to differences to be considered in the approach to treatment of adults and children.

All the interventions managed to reduce the intensity of headaches,\textsuperscript{16–18,23,25–27,29} except the self-acupressure pillow with a combination of MT (cervical and upper thoracic SMT, mobilizations, trigger point compression, and massage).\textsuperscript{28} Applying translatory vertebral mobilization achieved immediate improvement after a single session,\textsuperscript{27} possibly because the mechanical stimulus of this technique could activate the pain inhibitory systems causing immediate hypalgesic effects. Both with the Jones technique\textsuperscript{26} and with ischemic compression,\textsuperscript{23} significant improvements were obtained after four sessions. This is probably because both techniques act by changing local blood flow, improving ischemia, hypoxia, and increasing the presence of analgesic substances.\textsuperscript{6} In addition, MT techniques involving gradual pressures (such as those mentioned previously) allow the fascia to reorganize focal adhesions and macromolecule complexes (such as hyaluronic acid) to return to their healthy states.\textsuperscript{35–37}

Interventions with SMT\textsuperscript{16–18} managed to reduce the intensity of CH to less than two points of 10 when applying between 10 and 18 sessions\textsuperscript{16,17} up to 1 year after treatment. Jull et al.\textsuperscript{38} after 1 year of follow-up, demonstrated that SMT and specific exercise are effective in reducing pain intensity but that their combination does not lead to additional improvements. The studies that achieved a greater reduction in pain intensity\textsuperscript{18,38} used fewer sessions (between 6 and 8) than the others.\textsuperscript{16,17} These data indicate that a greater number of SMT sessions is not necessarily better for reducing CH.

Headaches can disable a person from carrying out daily activities, which is why many of the investigations analyzed studied the degree of disability.\textsuperscript{16,19–22,26,28} All the interventions reduced this variable except the one that included a combination of SMT, mobilizations, trigger point compression, and massage.\textsuperscript{28} Although they used a treatment similar to the rest, they may not have found significant changes because both groups received MT but only one used the self-acupressure pillow. Another option is that it was owing to the characteristics of the sample: it was the only article that included patients with a diagnosis of both CH and tension-type headache, and this lack of specificity in the choice of the sample could have caused the difference in the results obtained. Finally, it could also be owing to the assessment instruments: this study was the only one that used the Headache Activities of Daily Living Index, a variation of the Neck Disability Index that is less widely used than the Headache Impact Test\textsuperscript{16,21} or the Headache Disability Index.\textsuperscript{19,20,22,26}

Among the articles that studied the frequency of headaches,\textsuperscript{16–18,23,28,29} those that carried out a follow-up of more than 40 weeks stand out: SMT was applied in two of them\textsuperscript{16,17} and another study implemented a personalized treatment with cervical mobilizations, exercises for cervical and oculomotor ROM, and CCF and postural correction.\textsuperscript{29} Other studies achieved improvements with ischemic compression of the sternocleidomastoid in only four sessions\textsuperscript{25} and with neural mobilization of the occipital nerve\textsuperscript{26} after only 1 week. In the study by Vernon et al.,\textsuperscript{28} the frequency of CH was reduced more in the group that did not use the self-acupressure pillow, so it was not an effective device for CH. Therefore, ischemic compression and occipital nerve mobilization combined with stretching and exercise reduces CH almost immediately, and SMT appears to reduce the number of CH days in the long term.

It has been reported that patients with CH have weaker deep neck flexor muscles than patients with other types of headaches\textsuperscript{39} that are compensated for by tension in the sternocleidomastoid muscles.\textsuperscript{10} These two investigations may explain the beneficial effects of ischemic compression on this muscle.\textsuperscript{23} Most studies included some pattern of active CCF exercise, based on the aforementioned alteration of muscle activation in these patients and on the fact that
these exercises increase the activity of the deep muscles of the neck and shoulders, reducing fatigue and the tone of the superficial muscles. In addition, the increase in endorphins that occurs after training and better neuromuscular control can reduce pain and the frequency of CH. Owing to the efficacy that therapeutic exercise has been shown to have, strengthening through CCF as an adjunct to MT treatment may be key to achieving the best benefits for these patients; however, this has not been the subject of study in the present review.

Neck pain is a common symptom in CH, and with only four sessions of the Jones technique on the trapezius, a greater reduction in neck pain was achieved than with 10 sessions of neural mobilization of the occipital nerve; however, its frequency and intensity was also reduced with long-term SMT. Disability caused by neck pain improved with both SMT and Maitland mobilizations and exercise, although more so with SMT. It has been suggested that manipulation may also stimulate receptors in the deep paraspinal musculature, and it is likely that mobilization stimulates receptors in superficial muscles, which may explain the results of this study. Svedmark et al., with customized treatment, achieved a significant short- and long-term reduction in the disability caused by neck pain. Therefore, it appears that the Jones technique and the combination of various MT techniques (muscle energy techniques, SMT, stretching, Mulligan's SNAGs, and mobilizations) with exercise improves neck pain associated with CH. Consistent with these findings, Javaid et al. stated that conventional physiotherapy (according to the Chartered Society of Physiotherapy) with the Jones technique is more effective in reducing pain and disability and improving ROM in the cervical region than pharmacological treatment. Quality of life was evaluated in only two studies and in different ways: in one using the European Quality of Life-5 Dimensions, no improvement was achieved after 18 sessions of SMT, and in another using the Dizziness Handicap Inventory, improvement occurred after the application of Mulligan's SNAGs.

Medication intake was analyzed on only two occasions. In the study by Haas et al., there was no change; and in the study by Dunning et al., a decrease in drug intake was identified. It is possible that the difference between these two studies that applied SMT is because they used different diagnostic criteria for CH; some studies that were analyzed used the criteria of the Cervicogenic Headache International Study Group (CHISG) and others used those of the International Headache Society. According to previous research, diagnostic accuracy is greater with the CHISG criteria, because their criteria guide clinical practice more adequately. However, this deduction does not correspond to the choice of most of the articles analyzed (the majority of whom chose the criteria of the International Headache Society). Given the previous facts, it seems that there is no consensus as to the most appropriate diagnostic criterion, but it could explain why two interventions that applied SMT did not obtain similar results.

Therefore, for the treatment of CH with MT, the most effective interventions are those that combined different Muscle energy techniques, SMT in C1-C2-C3, and Mulligan's SNAGs in C1-C2. To achieve immediate relief of symptoms, the most effective techniques were the Jones technique on the trapezius and ischemic compression on the sternocleidomastoid. For such relief to last over time, SMT should be added at C1-C2 and/or C3 and, if possible, combined with strengthening exercises of the deep neck flexors. All these indications are the result of research findings with level I of evidence according to the Oxford scale and more than four points on the Jadad scale. Particularly, it seems that more treatment sessions do not result in greater improvements; the most beneficial pattern was that of one to two sessions per week for 6 weeks. In addition, if the patient presents signs and symptoms in the cervical region, the inclusion of mobilization techniques, strengthening exercises, and stretching of the neck musculature is of special interest.

This review has certain methodological limitations that should be recognized, such as the inclusion of studies published only in the last 5 years, quasi-experimental studies, studies with small sample sizes that reduce the generalizability of the results obtained, and the small number of studies that analyze long-term results and obtaining a low kappa concordance index between both authors after the first stage of full-text selection. For all these reasons, and with a view to the development of future research, it would be necessary to objectively define, by means of trials of sufficient methodological quality, the diagnostic criteria for CH and to compare more MT techniques and the efficacy of different combinations of these techniques in patients with acute and chronic diagnosis and in populations of different age ranges, and to clarify whether the behavior of CH symptoms and the effect of MT techniques is different in both sexes. At the same time, this review provides relevant data by considering among its results a great diversity of MT techniques and a multitude of variables related to the symptoms of CH, beyond the frequency and intensity of the headaches themselves. In addition, future research should evaluate the usefulness of the MT therapeutic approach in the treatment of other types of headaches with myofascial components, such as migraine without aura.

CONCLUSIONS

The MT techniques could be effective in the treatment of patients with CH. The techniques evaluated included SMT, Mulligan's SNAGs, ischemic trigger point compression, suboccipital musculature relaxation, Jones technique, and vertebral translatory mobilization, and all of them improve symptoms caused by CH.

Among the wide variety of methods and techniques that have been evaluated, upper cervical SMT appears to be the most effective. In the short term, the Jones technique on the trapezius and ischemic compression on the sternocleidomastoid achieve immediate improvements, whereas adding SMT to the treatment can maintain long-term results. In addition, the combination of different techniques, such as muscle energy techniques, SMT, and Mulligan's SNAGs, are interesting approaches for the treatment of CH. Strengthening of the deep neck flexors seems to play a fundamental role in the recovery of patients with this condition.
CONFLICT OF INTEREST
The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS
Study concept and design: Patricia Núñez-Cabaleiro, Raquel Leirós-Rodríguez. Acquisition of data: Patricia Núñez-Cabaleiro, Raquel Leirós-Rodríguez. Analysis and interpretation of data: Patricia Núñez-Cabaleiro, Raquel Leirós-Rodríguez. Drafting of the manuscript: Patricia Núñez-Cabaleiro, Raquel Leirós-Rodríguez. Revising it for intellectual content: Patricia Núñez-Cabaleiro, Raquel Leirós-Rodríguez. Final approval of the completed manuscript: Patricia Núñez-Cabaleiro, Raquel Leirós-Rodríguez.

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The data presented in this study are available on request from the corresponding author.

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