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Review Article

Chronic Primary Headache Subjects Have Greater Forward Head Posture than Asymptomatic and Episodic Primary Headache Sufferers: Systematic Review and Meta-analysis

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Abstract

Objective. To summarize the cervical physical examination characteristics in subjects with chronic primary headache and compare those with a healthy population and a population with episodic primary headache. **Design.** Systematic review and meta-analysis. **Subjects.** Humans ≥18 years old. At least one of the study groups should be constituted by subjects diagnosed with one of the chronic primary headache subtypes according to the International Classification of Headache Disorders, 3rd Edition. **Comparison.** Neck physical examination outcomes of subjects with chronic primary headache compared with a healthy population or subjects with episodic primary headache. **Outcomes.** Forward head posture (FHP), cervical range of movement, motor control, neck muscle activity, and reproduction and resolution of symptoms. **Methods.** Two reviewers assessed independently the MEDLINE, EMBASE, WOS, MEDES, PEDro, and CINAHL databases to select observational studies. First, both implemented an agreement for a search strategy. Then, they screened independently for duplicates, titles, abstracts, and full-text information. A meta-analysis was conducted to compare measures between groups. **Results.** Twelve studies (N = 1,083) with moderate quality (mean ± SD = 7.75 ± 1.48 on the Newcastle Ottawa Scale) were selected for the qualitative analysis. The meta-analysis showed that patients with chronic primary headache presented greater forward head posture than asymptomatic participants (N = 275, Hg = 0.68, 95% CI = 0.25–1.1, Z = 3.14, $P < 0.01$) and patients with episodic primary headache (N = 268, Hg = 0.39, 95% CI = 0.13–0.65, Z = 2.98, $P < 0.01$). **Conclusions.** There is moderate to strong evidence that patients with chronic primary headache present greater FHP than asymptomatic individuals and moderate evidence that patients with chronic primary headache present greater forward head posture than those with episodic primary headache.

Key words: Chronic Primary Headache; Cervical Spine; Posture; Physical Examination

Introduction

Primary headaches are those that have no other cause to justify their existence, unlike secondary headaches, which assume a clinical pattern originating from another recognizable cause [1]. Primary headaches include migraine, tension-type headache, and trigeminal autonomic cephalalgias like cluster headache, as defined by the International Classification of Headache Disorders, 3rd

Edition (ICHD-3) and the National Institute for Health and Care Excellence (NICE) [2,3]. Migraine is defined as a recurrent headache that manifests itself in attacks lasting from four to 72 hours, with typical characteristics of unilateral localization, pulsatile type, moderate or severe intensity, aggravated by physical activity, and associated with nausea and/or photophobia and phonophobia [2,3]. On the other hand, tension-type headache is typified by episodes of headache, usually bilateral, of the oppressive type, with mild to moderate intensity, lasting from minutes to days. The pain does not worsen with regular physical activity and is not associated with nausea, although photophobia or phonophobia might occur [2,3]. Trigeminal autonomic cephalalgias are defined as a headache with unilateral characteristics and with parasympathetic signs on the ipsilateral side, typified by short-lasting attacks of severe intensity [2,3]. Chronic headaches are those that occur ≥15 days per month, whereas episodic headaches are those that occur <15 days a month [2,3].

Globally, the estimated percentage of people with tension-type headache and migraine is 42% and 11%, respectively, whereas the percentage of daily chronic primary headache (CPH) is estimated at 3% [4]. According to the World Health Organization (WHO), headache is among the 10 most disabling conditions [5]. People with chronic tension-type headache (CTTH) and/or chronic migraine (CM) have limited quality of life and suffer from psychosocial disorders, and their capacities are impaired, implying a high cost of resources and a global burden [2,6,7]. Several studies have shown that patients with primary headache can also have neck pain [8,9].

Several studies suggest the theory that central sensitization, specifically of the trigemino-cervical complex, and alteration of the inhibitory pain mechanisms are involved in the pain experience of patients with CPH [10–12]. Recent evidence has confirmed these theories by showing electromyographic changes in the nociceptive flexion reflex and blink reflex, increased wind-up ratios, and a decrease of the pressure pain threshold in patients with CPH [13–15].

In addition, central sensitization may be influenced by nociceptive inputs from peripheral structures. In this sense, it is well established that the upper cervical nerve roots (C1–C3) converge with the trigeminal inputs via second-order neurons in the caudalis subnucleus of the trigeminal-spinal nuclei [16–18]. Thus, it may be that nociceptive inputs from the upper cervical region contribute to triggering headache episodes or that chronic headaches could lead to altered physical cervical function [17,18].

For that reason, physical examination of patients with primary headache is commonly performed by a physician or a physical therapist and includes an assessment of the cervical region, including forward head posture (FHP) [19,20], cervical range of movement [20], flexion-rotation test [20,21], and motor control and muscular activity of the cervical region [20,22,23]. Examinations can also include an assessment of the myofascial trigger points of the craniofacial and cervical region [20]. However, there is currently a lack of evidence with which to compare or summarize the features of the cervical musculoskeletal function most commonly found in patients with CPH.

Therefore, the main objective of this research is to meta-analyze the differences in FHP in CPH subjects compared with asymptomatic and episodic primary headache subjects.

Method

Data Sources and Searches

The protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO via number CRD42018114870) and performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards protocol [24].

To avoid bias, two independent reviewers (IE and MG) conducted the search, implementing an agreement for the search strategy and study selection (see *Strategy Selection* in the Supplementary Data). The MEDLINE, EMBASE, WOS, MEDES, PEDro, and CINAHL databases were assessed without language and temporal filters, with the search ending on October 18, 2018.

The search strategy performed by reviewer 1 in MEDLINE was: ((((((((((headache disorder, primary[MeSH Terms]) OR disorder, migraine[MeSH Terms]) OR headache, tension type[MeSH Terms]) OR cephalalgia, trigeminal autonomic[MeSH Terms]) OR chronic migraine) OR chronic tension type headache) OR cluster headache, chronic[MeSH Terms]) OR chronic cephalalgia, trigeminal autonomic)) AND (((((((((((physical examination[MeSH Terms]) OR joint range of motion[MeSH Terms]) OR passive range of motion[MeSH Terms]) OR active range of motion) OR pain threshold[MeSH Terms]) OR pressure pain threshold) OR flexion rotation test) OR myofascial trigger point pain[MeSH Terms]) OR motor control) OR pain provocation test) OR muscle strength[MeSH Terms])) AND ((((spine[MeSH Terms]) OR cervical spine) OR neck) OR cervical).

Reviewer 2 performed the next equation in MEDLINE: ((((((spine[MeSH Terms]) OR cervical spine) OR neck) OR cervical)) AND (((((((((((physical examination[MeSH Terms]) OR joint range of motion[MeSH Terms]) OR passive range of motion[MeSH Terms]) OR active range of motion) OR pain threshold[MeSH Terms]) OR pressure pain threshold) OR flexion rotation test) OR myofascial trigger points pain[MeSH Terms]) OR motor control) OR pain provocation test) OR muscle strength[MeSH Terms])) AND ((((((((headache disorder, primary[MeSH Terms])

OR migraine headache[MeSH Terms]) OR headaches, tension type[MeSH Terms]) OR chronic cluster headache[MeSH Terms]) OR cephalalgias, trigeminal autonomic[MeSH Terms]) OR chronic migraine) OR chronic tension type headache) OR chronic trigeminal autonomic headache.

Likewise, the same search strategy was adapted to perform the same searches of the EMBASE, WOS, MEDES, PEDro, and CINAHL databases.

Study Selection

Studies were included if they were cross-sectional, case–control, or cohort observational and reported outcomes of a cervical musculoskeletal physical examination (FHP, active or passive range of motion, presence myofascial trigger points, cervical muscle performance, or reproduction and resolution of symptoms tests) in patients diagnosed with CPH according to the ICHD [2,25–27]. Additionally, the studies had to show comparisons between a CPH group and an asymptomatic group (AG), episodic primary headache group, and/or cervicogenic headache group. Studies classified as pilot studies and those that did not have a comparison group of the above were excluded.

Data Extraction and Quality Assessment

Two investigators (IEG and MGP) conducted the entire selection process independently. As a first step, a duplicate study screening of all the databases was carried out. Next, each reviewer performed the first screening filter, excluding studies according to the study title information. Then, each reviewer proceeded to exclude studies according to the information provided in the abstract. When the title or abstract did not contain enough information to warrant its exclusion, that study would progress to the next screening phase. In this next phase, the studies that overcame the previous phases were read in full text, and those that fulfilled all the inclusion criteria were selected. After the last screening phase, all authors participating in this review met to analyze, one by one, each of the studies on which the two reviewers did not agree to reach a consensus.

For the methodological quality assessment, the Newcastle-Ottawa Scale (NOS) was adapted for cross-sectional studies [28]. The NOS for cross-sectional studies is appropriate for reviews that include a large volume of studies because it is short and has moderate reliability [29]. The NOS scale has a maximum of 10 points, where ≤ 5 points means high risk of bias. The scale assesses three main aspects: the selection of the sample, the comparability between groups, and the outcome presentation, assigning a value of 5, 2, and 3 stars, respectively, to each of the three aspects. In this sense, we were able to qualify the methodological quality of the studies as follows:

- Good: 3 or 4 stars in the selection domain, 1 or 2 stars in the comparability domain, and 2 or 3 stars in the exposure domain.
- Moderate: 2 stars in the selection domain, 1 or 2 stars in the comparability domain, and 2 or 3 stars in the exposure domain.
- Bad: 0 or 1 star in the selection domain, 0 stars in the comparability domain, and 0 or 1 star in the exposure domain.

To avoid biases, two different experienced reviewers (HBA and AGM) performed the quality analysis independently. In cases of disagreement, the whole research group intervened in a consensual way to solve it. Inter-rater concordance was analyzed using Cohen's Kappa coefficient ($\kappa > 0.7$ means a high level of agreement between the two evaluators, 0.5–0.7 means a moderate level, and <0.5 means a low level) [30].

Data Synthesis and Analysis

Qualitative Analysis

For the qualitative analysis of the selected studies, the adaptation proposed by La Touche et al. was used, which was an adaptation of classification criteria given by Van Tulder et al. [31,32]. The levels of evidence were categorized into five levels, as follows:

- Strong evidence: consistent findings among multiple high-quality case–control studies and/or cohort studies and/or cross-sectional studies (at least three of these studies).
- Moderate evidence: consistent findings from multiple low-quality case–control studies and/or cohort studies and/or cross-sectional studies or one high-quality case–control study and/or cohort study.
- Limited evidence: one low-quality case–control study and/or cohort study and/or at least two cross-sectional studies, also of low quality.
- Contradictory evidence: inconsistent findings among multiple studies (case–control and/or cohort and/or cross-sectional studies).
- No evidence: no case–control and/or cohort and/or cross-sectional studies.

Quantitative Analysis

The statistical analysis was conducted using Meta-analysis with Interactive Explanations (MIX; version 2.0). The same inclusion criteria were used for the meta-analysis, although the latter included three more criteria: 1) in the results, there was detailed information regarding the comparative statistical data (mean, SD, and 95% confidence interval) of the different variables related to the examination of the neck musculoskeletal dysfunction; 2) a minimum methodological quality (NOS score) was required [28], with at least six points for the cross-sectional studies and four points for case–control and cohort studies; and 3) data of the analyzed variables were represented in at least three studies.

Presentation of summary statistics in the form of forest plots was used [33]. Forest plots involve a weighted compilation of all the standardized mean differences

(SMDs) and corresponding 95% CIs reported by each study and provide an indication of heterogeneity between studies. Estimates on the right side of the forest plots indicated increased physical cervical dysfunction in patients with CTTH and CM and were labeled "FHP," whereas point estimates on the left side represented the opposite situation and were labeled "No FHP."

The statistical significance of the pooled SMDs was examined as Hedges' g (HG) to account for possible overestimation of the true population effect size in small studies [34]. The magnitude of HG was interpreted according to a four-point scale: 1) <0.20 = negligible effect; 2) 0.20–0.49 = small effect; 3) 0.50–0.79 = moderate effect; and 4) ≥0.80 = large effect [35].

The degree of heterogeneity among studies was estimated by Cochran's Q statistic test ($P < 0.05$ is considered significant) and the inconsistency index (I^2). Thus, I^2 >25% is considered to represent a small heterogeneity, I^2 >50% a medium heterogeneity, and I^2 >75% a large heterogeneity [36,37]. The I^2 index is complementary to the Q test, but with a small number of studies I^2 prevails if it shows large heterogeneity [37]. Therefore, an analysis was considered heterogeneous when fulfilling one or both conditions: 1) Q test was significant ($P < 0.05$); and 2) Q test was not significant ($P > 0.05$), but the result of I^2 was >50%.

In case of heterogeneous studies, a random-effects model was conducted in the meta-analysis of the heterogeneous studies to obtain a pooled estimate of effect. On the other hand, if there was no heterogeneity, the meta-analysis was performed using a fixed-effects model [38].

In addition, to analyze whether there was bias in the publication of studies (i.e., if more studies are published that reflect significant differences between groups, while those that do not obtain significant results are not published), a funnel plot was used. Furthermore, Egger's regression test was used to test the publication bias [39,40].

Results

Flow of Studies Through the Review

The electronic database search was conducted by two reviewers independently and is shown in detail in Figure 1.

Study Characteristics and Demographics

All the selected studies had a cross-sectional design, and no cohort or case–control studies were selected because they did not meet the inclusion criteria [19–23,41–47].

Four studies compared the CTTH group only with an AG [19,44–46]. Two studies compared the CTTH group with an episodic tension-type headache (ETTH) group and an AG [22,23]. Two studies compared the CM group with an episodic migraine (EM) group [43,47], and four studies compared the CM group with an EM group and an AG [20,21,41,42].

All studies selected were performed in a group of patients who had been diagnosed with CTTH or CM, according to the ICHD-3 [2,25,26,48]. No studies were found on chronic trigeminal autonomic cephalalgias or other primary headache disorders that met the criteria of this systematic review.

A total of 1,083 participants were assessed (CM, N = 187; EM, N = 394; CTTH, N = 155; ETTH, N = 50; AG, N = 297; 55.55% women); however, one study did not provide the men-to-women ratio [41]. Six studies assessed CTTH participants [19,22,23,44–46], of which four studies showed data related to the time evolution of the patient's headache (9.15 ± 9 years/patient) [19,44–46], four studies showed the weekly frequency of the headache (4.83 ± 0.91 days/wk) [22,23,44,45], five studies showed the intensity on the examination day (5.10 ± 1.33 cm on a 10-cm visual analog scale [VAS]) [22,23,44–46], and four studies showed episode duration (8.50 ± 4.47 hours/d) [20,22,23,44].

On the other hand, six studies assessed patients with CM [20,21,41–43,47], of which five studies showed demographic data related to the time evolution of the patient's headache (19.06 ± 8.7 years) [20,21,41,42,47]. Six studies showed the monthly frequency of the headache (20.83 ± 5.91 days/mo) [20,21,41–43,47], five studies showed the pain intensity on the examination day (7.98 ± 2.46 cm on a 10-cm VAS) [21,41–43,47], and one study showed episode duration (17 ± 8.52 hours/d) [20].

Quality Assessment

The 12 studies showed an average methodological quality (7.75 ± 1.48 out of 10 possible points) and a range of 4 to 9 points [19–23,41–47].

Two experienced reviewers independently performed the analysis, recording a high intertester reliability ($k = 0.92$). All disagreements between reviewers were then resolved by research group consensus. Finally, 10 studies showed good methodological quality [19–23,41–44], and two studies showed low quality (Table 1) [45,46].

Outcome Measures

The characteristics of the sample, variables, measuring instruments, procedure, structure, and movement or orthopedic test results of studies are shown in Table 2. The following describes the characteristics of how each variable was measured.

- Forward head posture*:* Five studies assessed FHP [19,21,22,44]. One study used a ruler to measure FHP [20]. The other four studies measured FHP using software that assessed the angle formed by a horizontal line running from the spinous process of C7 and an oblique line from the spinous process of C7 to the left ear tragus [19,21,22,44].

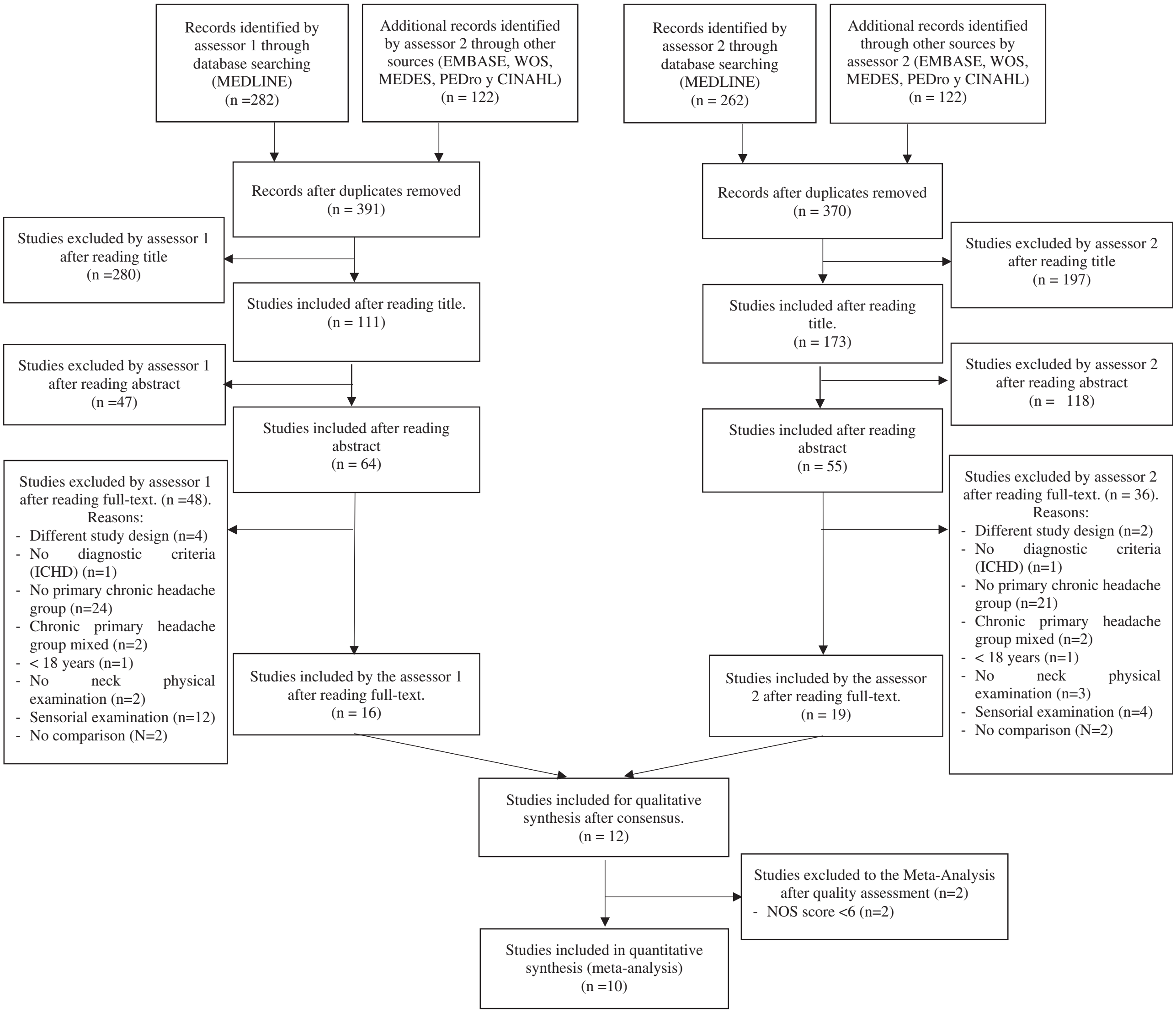

Figure 1. Flow diagram.

- Active range of motion*:* Four studies assessed the neck active range of motion using a cervical goniometer (CROM) [20,21,43,44], and one study used a digital inclinometer [22]. All the studies assessed patients in a sitting position, and all but one showed outcomes of all the physiological movements [20]. Luedtke et al. showed the total active range of motion, adding together each of the movements [20].
- Myofascial trigger points*:* Five studies assessed the presence of myofascial trigger points, and all of them did so manually [20,22,23,46,47]. Four of these showed the total number of myofascial trigger points [20,22,23,44], and two of them registered the participants who had active or latent myofascial trigger points [46,47]. All five studies assessed the upper trapezius and the sternocleidomastoid muscles [20,22,23,46,47], four of them assessed suboccipital muscles [20,22,46,47], and one assessed the splenius capiti [47].
- Passive range of motion and reproduction and resolution of symptoms*:* Two studies examined passive accessory intervertebral movements and passive upper cervical spine rotation during the flexion rotation test [20,21]. To assess cervical dysfunction with passive accessory intervertebral movements, both studies recorded the subjective feeling of hypomobility by the assessor. Meanwhile, for the flexion rotation test, the authors used a CROM to measure the rotation range of motion. Both studies recorded whether either test provoked any symptoms [20,21].
- Luedtke et al. recorded the subjective perception of hypomobility and reproduction of symptoms in passive physiological intervertebral movement as well as an orthopedic test of the upper cervical quadrant [20]. Similarly, Luedtke et al. examined reproduction and resolution of the headache by performing an orthopedic test in which the assessor performed a unilateral postero-anterior movement from the C1 to C3 joints in a sustained manner [20].
- Muscle performance and motor control: Of the heterogenic methodologies in the five studies that assessed muscle activity and motor control [20,23,41,42,45], two studies used a hand dynamometer to measure the maximum voluntary isometric contraction (MVIC) during both cervical flexion and extension [41,45]. Four studies used surface electromyography (EMG) to measure antagonist muscle activity during an MVIC [23,41,42,45]. Similarly, Sohn et al. measured the

Table 1. Quality assessment of studies (NOS score of included studies)

Authors (Year)	S1: Representativeness of the Sample	S2: Sample Size	S3: Nonrespondants	S4: Ascertainment of Exposure	Ca: Study Controls for Most Important Factor	Cb: Study Controls for Additional Factor	O1: Ax of Outcome	O2: Statistical Test	Total
Fernandez-De-Las-Peñas et al. (2006) [44]	★		★	★★	★	★	★★	★	9/10
Fernandez-De-Las-Peñas et al. (2008) [45]	★			★★	★	★			5/10
Luedtke et al. (2018) [20]	★	★	★	★★	★	★	★★		9/10
Florencio et al. (2015) [41]	★		★	★★	★	★	★★	★	9/10
Sohn et al. (2013) [23]	★		★	★★	★	★	★★	★	9/10
Sohn et al. (2010) [22]	★			★★	★	★	★★		7/10
Carvalho et al. (2014) [43]	★		★	★★	★	★	★★		8/10
Ferraccini et al. (2017a) [21]	★		★	★★	★	★	★★		8/10
Ferraccini et al. (2017b) [47]	★		★	★★	★	★	★★	★	9/10
Fernández-De-Las-Peñas et al. (2005) [19]	★		★	★★			★★	★	7/10
Florencio et al. (2016) [42]	★		★	★★	★	★	★★		8/10
Fernández-De-Las-Peñas et al. (2007) [46]	★			★★			★★		5/10

NOS = Newcastle-Ottawa Scale.

agonist muscles during an MVIC [23]. Luedtke et al. measured motor control with the cranio-cervical flexion test using biofeedback [20], whereas Florencio et al. used surface EMG to measure the same test [42]. Finally, one study measured the time necessary to reach maximum peak force [41].

Data Analysis

Qualitative Analysis

To describe the qualitative analysis of the results, the studies that presented a clinical and methodological homogeneity have been grouped:

Forward Head Posture

- Limited evidence: Two studies (N = 151) showed that patients with CTTH had more FHP than asymptomatic patients [19,22]. However, two other studies (N = 305) reported no differences between patients with CM and EM and asymptomatic patients [20,21].
- No evidence: One study (N = 101) showed no differences between patients with CTTH and ETTH when measuring FHP [22].

Active Range of Motion

- Strong evidence: Three studies (N = 439) showed that no differences existed in active range of motion between patients with CM and EM [20,21,43].
- Limited evidence: Two studies (N = 151) reported that patients with CTTH had less active range of motion during rotation than AGs [19,22]. Two studies (N = 304) reported that patients with CM had less active range of motion than AGs [20,21].
- Contradictory evidence: One study, from Fernández de las Peñas et al. (N = 41), reported that patients with CTTH had less flexion, extension, and side flexion active range of motion than AGs [19]. However, Sohn et al. (N = 101) did not find differences between these groups [22].
- No evidence: One study (N = 101) showed that patients with CTTH had less active range of motion during rotation than patients with ETTH [22].

Myofascial Trigger Points

- Limited evidence: Two studies (N = 354) showed that there is not a greater number of myofascial trigger points in patients with CM than in patients with EM [20,47].
- Contradictory evidence: Three studies (N = 191) reported a greater number of myofascial trigger points in patients with CTTH than in AGs [23,44,46]. Meanwhile, Sohn et al. (N = 41) did not find differences between those groups [22].
- No evidence: Only one study (N = 211) reported that patients with CM had a greater number of myofascial trigger points than AGs [20].

Passive Range of Motion and Reproduction and Resolution of Symptoms

- Limited evidence: Two studies (N = 304) reported no differences between patients with CM and EM when the assessor

Table 2. Characteristics of each study group: Procedures, results, and differences in the cervical examination between each study group

Author (Year)	Chronic Primary Headache Group	Comparative Group	Measures	Tools	Movement/Structure/Test	Outcomes/Comparison
Fernández-De-Las-Peñas et al. (2006) [44]	G1 (CTTH) (N = 25) M/F = 17/8 40+/-16 y	G2 (AG) (N = 25) M/F = 16/9 38+/-9 y	MTrPs	Manual examination	Right SCM	More subjects in G1 with active MTrPs than in G2 ($P = 0.001$)
					Left SCM	More subjects in G1 with active MTrPs than in G2 ($P = 0.003$)
					Right UT	More subjects in G1 with active MTrPs than in G2 ($P = 0.001$)
					Left UT	More subjects in G1 with active MTrPs than in G2 ($P = 0.003$)
			FHP	Photographic camera	Cranio-vertebral angle	Lower cranio-vertebral angle in those subjects with active MTrPs in left SCM ($P < 0.05$)
					Cranio-vertebral angle	NSD among G1 subjects who had active MTrPs and those with latent MTrPs ($P < 0.05$)
Fernández-De-Las-Peñas et al. (2008) [45]	G1 (CTTH) (N = 9) M/F = 0/9 40.1+/-7.2 y	G2 (AG) (N = 10) M/F = 0/10 39.9+/-6.6 y	Strength during MVIC	Load cellsincorporated into a device placed in the forehead	MVIC in extension MVIC in flexion	G1 less strength than G2 ($P = 0.008$) G1 less strength than G2 ($P = 0.008$)
			ARV of extensor and flexor muscles during flexion and extension MVIC	Surface EMG	Splenius capiti and SCM/extension	Greater activation of SCM in G1 than G2 ($P = 0.029$); NSD in splenius capiti
					Splenius capiti and SCM/flexion	Greater activation of left splenius capiti in G1 than in G2 ($P = 0.02$); NSD in SCM
Luedtke et al. (2018) [20]	G1 (CM) (N = 50) M/F = 4/46 39+/-12.22 y	G2 (EM) (N = 88) M/F = 8/80 39+/-12.29 y G3 (AG) (N = 73) M/F = 12/61 40+/-13.39 y	AROM	CROM	Cervical region,total summation of flexion, extension, rotations, and side flexions	Less ROM in G1 ($P = 0.038$) and G2 ($P = 0.023$), both compared with G3 NSD between G1 and G2 ($P = 0.098$)
			MTrPs	Manual examination	SCM, T, and SUB muscles	More MTrPs in G1 ($P < 0.0001$) and G2 ($P < 0.0001$), both compared with G3 NSD between G1 and G2 ($P = 0.189$)
			FHP	CROM	Distance between the cut-points of the verticals of C7 and the bridge of the nose with the horizontal	NSD between groups ($P > 0.05$)
			PPIVMs	Manual examination	Cervical region (occipital-C2) Flexion, extension, rotations, and side flexions	NSD between groups ($P > 0.05$)
			PAIVMs	Manual examination	Cervical region (occipital-C3) Central and unilateral posteroanterior mobilizations	Higher total score in G1 ($P < 0.0001$) and G2 ($P < 0.0001$) compared with G3NSD between G1 and G2 ($P = 0.924$)
			Upper cervical quadrant	Manual examination	Upper cervical region Combination of extension + rotation + side flexion ipsilateral of the upper cervical spine	Higher total score in G1 ($P = 0.001$) and G2 ($P = 0.024$) compared with G3NSD between G1 and G2 ($P = 0.217$)
			FRT	Manual examination	Upper cervical region Pain-free cervical rotation in both sides from maximum cranio-cervical and cervical flexion	Less ROM in G2 than G3 ($P = 0.000$)NSD between G1 and G2 ($P = 0.741$); NSD between G1 and G3 ($P = 0.083$)

(continued)

Author (Year)	Chronic Primary Headache Group	Comparative Group	Measures	Tools	Movement/Structure/Test	Outcomes/Comparison
			CCFT	Biofeedback(stabilizer)	Motor control of deep cervical flexors	Lower score in G1 ($P = 0.003$) and G2 ($P = 0.001$) compared with G3 NSD between G1 and G2 ($P = 1$)
			Reproduction and resolution of symptoms	Manual examination	C0-C3 joints Unilateral posteroanterior mobilization sustained	Higher score in G1 than G2 ($P = 0.003$) and G3 ($P < 0.0001$); higher score in G2 than G3 ($P = 0.002$)
Florencio et al. (2015) [41]	G1 (CM) (N = 21) M/F = – 34+/-30–39 y	G2 (EM) (N = 31) M/F = – 33+/-29–37 y G3 (AG) (N = 31) M/F = – 31+/-27–34 y	Maximum strength in MVIC	Hand dynamometer adapted	Flexion	NSD between groups ($P > 0.05$)
					Extension	Lower strength of G1 with respect to G2 and G3 ($P < 0.05$) measured in N
					Right-side flexion	NSD between G2 and G3 ($P > 0.05$)
					Left-side flexion	NSD between groups ($P > 0.05$)
			Time until reach the peak force	Chronometer	Flexion	Longer time of G1 with respect to G3 ($P < 0.05$) but not with respect to G2 ($P > 0.05$)
					Extension	NSD between groups ($P > 0.05$)
					Right-side flexion	NSD between groups ($P > 0.05$)
					Left-side flexion	Longer time of G1 with respect to G2 and G3 ($P < 0.05$)
			RMS	Surface EMG	MVIC: flexion	More EMG activity of the antagonist muscle in G1 and G2 compared with G3 ($P < 0.05$)
					MVIC: extension	NSD between groups ($P > 0.05$)
					MVIC: right-side flexion	NSD between groups ($P > 0.05$)
					MVIC: left-side flexion	NSD between groups ($P > 0.05$)
Sohn et al. (2013) [23]	G1 (CTTH) (N = 14) M/F = 0/14 55.93+/-5.48 y	G2 (ETTH) (N = 14) M/F = 0/14 55.07+/-5.21 y G3 (AG) (N = 13) M/F = 0/13 54.04+/-6.58 y	RMS	Surface EMG	Right SCM	Lower RMS in G1 compared with G3 ($P = 0.023$); NSD between G1 and G2 ($P > 0.05$); NSD between G2 and G3 ($P > 0.05$)
					Left SCM	Lower RMS in G1 compared with G2 ($P = 0.022$) and G3 ($P = 0.039$); NSD between G2 and G3 ($P > 0.05$)
					Right upper trapezius	NSD between groups ($P > 0.05$)
					Left upper trapezius	Lower RMS in G1 compared with G3 ($P = 0.044$); NSD between G1 and G2 ($P > 0.05$); NSD between G2 and G3 ($P > 0.05$)
			MDF		Right SCM	More MDF in G2 than G3 ($P = 0.045$); NSD between other groups ($P > 0.05$)
					Left SCM	More MDF in G1 than G3 ($P = 0.020$); NSD between other groups ($P > 0.05$)
					Right upper trapezius	NSD between groups ($P > 0.05$)
					Left upper trapezius	NSD between groups ($P > 0.05$)
			MTrPs	Manual examination	SCM	NSD between groups ($P > 0.05$)
					Upper trapezius	NSD between groups ($P > 0.05$)

(continued)

Author (Year)	Chronic Primary Headache Group	Comparative Group	Measures	Tools	Movement/Structure/Test	Outcomes/Comparison
Sohn et al. (2010) [22]	G1 (CTTH) (N = 23) M/F = 2/21 53.43+/-16.97 y	G2 (ETTH) (N = 36) M/F = 7/29 51.11+/-14.42 y G3 (AG)	MTrPs	Manual examination	SCM	NSD between groups ($P > 0.05$)
					Upper trapezius	Greater number of active MTrPs in G1 than in G2 ($P < 0.001$)
					SUB	Greater number of active MTrPs in G1 than in G2 ($P < 0.002$)
					Total summation	Greater number of MTrPs in G1 than in G2, and this with respect to G3 ($P < 0.001$)
		(N = 42) M/F = 8/34	FHP	Photographic camera	Cranio-vertebral angle	Greater angle in G1 than in G3 ($P = 0.011$); NSD between G2 and G3 ($P > 0.05$)
		51.69+/-16.18 y	AROM	Electronic inclinometer	Flexion	NSD between groups ($P > 0.05$)
					Extension	NSD between groups ($P > 0.05$)
					Right rotation	Less ROM in G1 than in G2 ($P = 0.001$) and G3 ($P = 0.000$); NSD between G2 and G3
					Left rotation	Less ROM in G1 than in G2 ($P = 0.003$) and G3 ($P = 0.000$); NSD between G2 and G3
					Right-side flexion	NSD between groups ($P > 0.05$)
					Left-side flexion	NSD between groups ($P > 0.05$)
Carvalho et al. (2014) [43]	G1 (CM) (N = 34) M/F = 2/32 39+/-9 y	G2 (EM) (N = 91) M/F = 9/82 37+/-10 y	AROM	CROM	Flexion	NSD between groups ($P > 0.05$)
					Extension	NSD between groups ($P > 0.05$)
					Right rotation	NSD between groups ($P > 0.05$)
					Left rotation	NSD between groups ($P > 0.05$)
					Right-side flexion	NSD between groups ($P > 0.05$)
					Left-side flexion	NSD between groups ($P > 0.05$)
Ferraccini et al. (2017a) [21]	G1 (CM) (N = 16) M/F = 0/16 44+/-13 y	G2 (EM) (N = 55) M/F = 0/55 41+/-12 y G3 (AG) (N = 22)	AROM	CROM	Flexion	NSD between groups ($P > 0.05$)
					Extension	NSD between groups ($P > 0.05$)
					Right rotation	Less right rotation in G1 and G2 with respect to G3 ($P > 0.001$)
					Left rotation	Less left rotation in G1 and G2 with respect to G3 ($P < 0.001$)
					Right-side flexion	NSD between groups ($P > 0.05$)
					Left-side flexion	NSD between groups ($P > 0.05$)
		M/F = 0/22 44+/-11 y	FRT	Manual examination	Upper cervical region Pain-free cervical rotation in both sides from maximum cranio-cervical and cervical flexion	Less ROM in G1 and G2 compared with G3 ($P < 0.001$)
			PAIVMs	Manual examination	C1-C3 central C0-C1 right C0-C1 left C1-C2 right C1-C2 left	NSD between groups ($P > 0.05$) in any of the analyzed movements

(continued)

Author (Year)	Chronic Primary Headache Group	Comparative Group	Measures	Tools	Movement/Structure/Test	Outcomes/Comparison
			JPE	CROM	Extension Right rotation Left rotation	NSD between groups ($P > 0.05$) in any movement
			FHP	Photographic camera	Cranio-vertebral angle in sitting (knee and hip 90° flexion) and standing position	NSD between groups ($P > 0.05$) in any of the analyzed positions
Ferraccini et al. (2017b) [47]	G1 (CM) (N = 45) M/F = 0/45 38+/-12 y	G2 (EM) (N = 98) M/F = 0/98 37+/-12 y	MTrPs	Manual examination	SUB SCM Upper trapezius Splenius capiti Total of MTrPs	NSD between G1 and G2 ($P > 0.05$) NSD between G1 and G2 ($P > 0.05$) NSD between G1 and G2 ($P > 0.05$) NSD between G1 and G2 ($P > 0.05$) NSD between G1 and G2 ($P > 0.05$)
Fernández-de-Las-Peñas et al. (2005) [19]	G1 (CTTH) (N = 25) M/F = 11/14 42+/-18 y	G2 (AG) (N = 25) M/F = 12/13 40+/-12 y	AROM	CROM	Flexion Extension Right rotation Left rotation Right-side flexion Left-side flexion	Less ROM in G1 than in G2 ($P < 0.01$) Less ROM in G1 than in G2 ($P < 0.01$) Less ROM in G1 than in G2 ($P < 0.01$) Less ROM in G1 than in G2 ($P < 0.01$) NSD between groups Less ROM in G1 than in G2 ($P < 0.01$)
			FHP	Photographic camera	Cranio-vertebral angle	Lower angle in G1 with respect to G2 ($P < 0.001$)
Florencio et al. (2016) [42]	G1 (CM) (N = 21) M/F = 0/21 34+/-9.76 y	G2 (EM) (N = 31) M/F = 0/31 33+/-11.22 y G3 (AG) (N = 31) M/F = 0/31 31+/-9.08 y	RMS	Surface EMG	SCM Anterior scalene Splenius capiti Upper trapezius	NSD between groups NSD between groups Grater activation in G1 than in G3 ($P < 0.01$), NSD between G1 and G2 Grater activation in G1 than in G3 ($P < 0.01$), NSD between G1 and G2
Fernández-de Las Peñas et al. (2007) [49]	G1 (CTTH) (N = 20) M/F = 11/9 36+/-11 y	G2 (AG) (N = 20) M/F = 13/7 35+/-9 y	MTrPs	Manual examination	Upper trapezius	More active MTrPs in G1 than in G2 ($P < 0.05$), NDS in latent MTrPs ($P > 0.05$)

AG = asymptomatic group; AROM = Active range of motion; CCFT = Craniocervical flexion text; CM = chronic migraine; CROM = cervical goniometer; CTTH = chronic tension-type headache; EM = episodic migraine; EMG = electromyography; ETTH = episodic tension-type headache; FHP = forward head posture; FRT = Flexion rotation test; JPE = Joint position error; MDF = Median frequency; MTrPs = myofascial trigger points; MVIC = maximum voluntary isometric contraction; NSD = No statistical differences; PAIVM = Passive Accessory Intervertebral Movements; ROM = range of motion; RMS = Root mean square; SCM = Sternocleidomastoid muscle; SUB = Suboccipitals muscle; UT = Upper trapezius muscle.

	CPH			Asymptomatics			Standardized mean		
Author (year)	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**differences (95% CI)**	**Weight**	**P-Value**
Luedtke et al (2018)	18.64	2.04	50	18.1	1.95	73	0.27 (-0.09; 0.63)	31.88%	0.14
Sohn et al (2010)	137.74	7.68	23	133.31	5.6	42	0.69 (0.17; 1.21)	25.42%	0.01
Fdez-Peñas et al (2005)	134.7	7.6	24	125.9	6.3	25	1.26 (0.65; 1.88)	22.09%	<0.01
Ferraccini et al (2017)	141.6	4.8	16	138.6	4.4	22	0.66 (-0.01; 1.32)	20.6%	0.05
Meta-analysis			**113**			**162**	**0.68 (0.25; 1.1)**	**100%**	**<0.01**

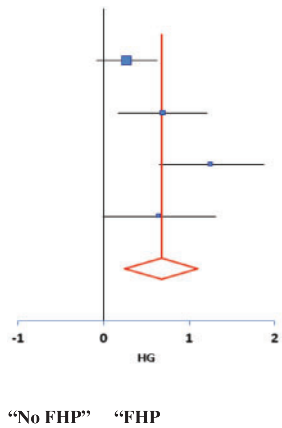

Figure 2. Synthesis forest plots: Chronic primary headache vs asymptomatic subjects. CPH = chronic primary headache; FHP = forward head posture; HG = Hedges' g.

measured passive accessory intervertebral movements [20,21].

- Contradictory evidence: One study (N = 93) reported that patients with CM had less rotation than patients with EM and AG, as measured with the flexion rotation test [21]. However, Luedtke et al. (N = 211) found no differences between patients with CM or EM and AGs [20]. Luedtke et al. (N = 211) reported cervical musculoskeletal dysfunction in patients with CM, measured through passive accessory intervertebral movements [20]. However, Ferraccini et al. (N = 93) reported no differences between groups [21].
- No evidence: Only one study (N = 211) showed that there were no differences between patients with CM and EM and healthy patients, measuring passive intervertebral movements [20]. In addition, this is the only study that assessed the cervical quadrant orthopedic test, reporting differences between patients with CM compared with patients with EM and AG. Luedtke et al. reported differences between patients with CM compared with patients with EM and AGs, measuring the reproduction and resolution of headache through the orthopedic test described by Watson and Drummond [20,49].

Muscle Performance and Motor Control

- Contradictory evidence: Fernández de las Peñas et al. (N = 19) reported greater surface EMG activity in CTTH patients' splenius capiti than in AGs in an MVIC [45]. Conversely, Sohn et al. (N = 41) reported lesser surface EMG activity compared with healthy individuals [23].
- No evidence: One study (N = 19) reported that patients with CTTH had less strength than healthy individuals, measuring flexion and extension MVIC with an adapted hand dynamometer [45]. The same authors reported that patients with CTTH had greater surface EMG activity in the antagonist muscles during weathered extension movement. One study (N = 41) reported more sternocleidomastoid muscle fatigue in patients with CTTH than in patients with ETTH and AGs in an MVIC [23]. One study (N = 211) reported poorer motor control in patients with CM than in AGs [20]. Florencio et al. (N = 83) reported less extension strength in an MVIC, longer time to reach peak force on that test, and more antagonist activity measured with surface EMG in patients with CM than in patients with EM and in healthy individuals [41]. Ferracini et al. (N = 93) reported no differences between CM, EM, and AG during the joint position error test [21]. One study (N = 83) reported more EMG activity in the antagonist muscles of patients with CM who were performing a cranio-cervical flexion test [41].

Meta-analysis Results

Meta-analysis of Forward Head Posture (Chronic Primary Headache vs Asymptomatic Groups)

Four cross-sectional studies (CTTH, N = 48; ETTH, N = 36; CM, N = 66; EM, N = 143; AG, N = 162) evaluated the FHP in patients with CPH compared with AGs [19–22].

A heterogeneity analysis performed using Cochran's Q showed a Q-value of 7.75 ($P = 0.05$). Meanwhile, the inconsistency index reported an I^2 of 61.3%. Thus, a random-effects model was performed. The meta-analysis of these four studies showed differences and moderate effect comparing the FHP between participants with CPH and AGs (N = 275, HG = 0.68, 95% CI = 0.25–1.1, Z = 3.14, $P < 0.01$) (Figure 2).

Furthermore, accordingly to Egger's test of asymmetry, the results suggested no significant evidence of publication bias for FHP analysis when comparing these groups (intercept = 4.66, $t = 2.06$, $P = 0.18$).

Meta-analysis of Forward Head Posture (Chronic Primary Headache vs Episodic Primary Headache Groups)

Three cross-sectional studies (CTTH, N = 23; ETTH, N = 36; CM, N = 66; EM, N = 143; AG, N = 137) evaluated FHP in patients with CPH compared with EPH [20–22].

A heterogeneity analysis performed using Cochran's Q showed a Q-value of 0.02 ($P = 0.99$). In addition, the inconsistency index reported an I^2 of 0%. Thus, a fixed-

Author (year)	CPH Mean	CPH SD	CPH Total	EPH Mean	EPH SD	EPH Total	Standardized mean differences (95% CI)	Weight	P-Value
Luedtke et al (2018)	18.64	2.04	50	17.88	1.74	88	0.41 (0.06;0.76)	54.56%	0.02
Sohn et al (2010)	137.74	7.68	23	134.99	7.61	36	0.36 (-0.17;0.89)	24.10%	0.18
Ferraccini et al (2017)	141.6	4.8	16	139.6	5.2	55	0.39 (-0.17;0.95)	21.33%	0.18
Meta-analysis			**89**			**179**	**0.39 (0.13;0.65)**	**100%**	**<0.01**

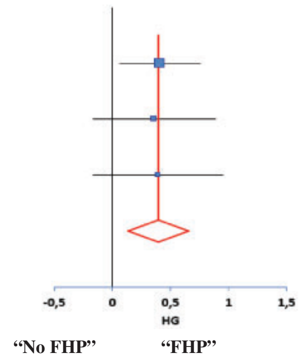

Figure 3. Synthesis forest plots: Chronic primary headache vs Episodic primary headache. CPH = chronic primary headache; EPH = episodic primary headache; FHP = forward head posture; HG = Hedges' g.

effects model was performed. The meta-analysis of these three studies again showed differences comparing the FHP between participants with CPH and EPH (N = 268, HG = 0.39, 95% CI = 0.13–0.65, Z = 2.98, $P < 0.01$) (Figure 3).

According to Egger's test, the results suggested no significant evidence of publication bias for analysis of FHP when comparing these groups (intercept = −0.34, t = −1.38, $P = 0.4$).

Discussion

The results of the present systematic review and meta-analysis have sought to demonstrate the presence of physical impairment in the cervical spine in patients with CPH.

At the beginning of the development of this systematic review, we could find few similar systematic reviews in the literature, but in recent months at least two new systematic reviews with similar characteristics have been published [50,51]. As has already been noted in the *Introduction* section, this circumstance is probably due to the fact that there are currently multiple published research studies in which physical dysfunction of the cervical spine and primary headache, such as CTTH and CM, have been directly related.

Despite these new publications, however, this study differs by providing new and interesting metadata on a total population of 1,083 participants.

Forward Head Posture

In relation to FHP, the results are not decisive, and only limited evidence has been observed to support the position that patients with CTTH present an increase in FHP compared with asymptomatic individuals; however, there are no differences when comparing CM groups with EM or AG. These results concur with those recently published by Liang et al. [50], in which it was reported that participants with CTTH had more FHP compared with controls. In addition, some quasi-experimental trials have shown that patients with headache have a higher (22.3%) passive protraction range than asymptomatic individuals [52]. This could have certain clinical implications related to the source of craniofacial symptoms from the upper cervical structures, such as the joints, ligaments, muscles, tendons, and cervical nerves, which could be in a state of overpressure produced by the FHP itself.

However, certain classic studies have been able to relate this clinical situation to patients with craniomandibular disorders [53]. The evidence available in the current situation that associates primary headache with FHP is very scarce, and in fact, no article has been found that had the objective of seeking such an association in patients with primary headache types other than tension-type or migraine headaches.

On another note, FHP was the only variable that, due to the inclusion criteria of this systematic review and meta-analysis and the quality characteristics of its studies, allowed a meta-analysis of the data. In this sense, the patients were grouped into CPH, EPH, and asymptomatic participants. By placing the patients in these groups, we could observe that the patients with CPH presented a higher FHP compared with the EPH and asymptomatic population.

Active Range of Motion

Active range of motion is one of the most important variables in joint function and is also considered one of the variables that best reflects patients' quality of life [54]. Limited evidence has been found indicating that patients with both CTTH and CM have less rotation than asymptomatic individuals. This clinical situation might be associated with alteration of the neuromusculoskeletal structures in patients with CTTH [55]. We must also consider that patients with chronic headache are the most affected by these structures. At the same time, cervical rotation movement requires greater involvement of the upper cervical spine (C1–C2) [55], and it is also the area that, from a neurophysiological point of view, is directly associated with the trigeminocervical complex [56].

Myofascial Trigger Points

The presence of myofascial trigger points in patients with headache is possibly the most studied musculoskeletal variable so far. Specifically, this review includes seven studies that have recorded this variable. However, the existence or not of myofascial trigger points, as well as their physiopathology and definition, has been widely discussed in recent years [57]. Unfortunately, although previous studies have proposed that myofascial trigger points could stimulate the trigeminal nucleus caudalis and thus precipitate a headache episode [58], this review has not been able to find sufficient evidence to support the existence of a greater number of myofascial trigger points in patients with chronic vs episodic migraine. This is also true in the comparison between chronic migraine and the asymptomatic population. The evidence is contradictory in the comparison between chronic CTTH patients and asymptomatic individuals. The low methodological quality of the studies in which this variable was registered has likely contributed significantly to the impossibility of establishing a reliable criterion to confirm this hypothesis in patients with headaches [45,46]. Therefore, concretely and related to myofascial trigger points, results should be taken with caution due to the risk of bias being slightly high.

Passive Range of Motion; Reproduction and Resolution of Symptoms

Although clinically, in the experience of the authors of this paper, such an exploration is of high importance, the results of this study show that the evidence is still limited and contradictory. The passive intervertebral range of cervical movement as an element of evaluation and treatment for patients with headache is a common practice in the physiotherapy approach. The importance of these tests lies mainly in the capacity of reasoning that allows the health professional to reproduce or resolve symptoms in the patient. In addition, current studies describing a reduction in range of motion in various exploratory tests in patients with CTTH are available [59].

Muscle Performance and Motor Control

Again, the evidence presented in this review shows us that the changes in muscle performance and motor control in patients with primary headache (migraines and tension-type headache) is contradictory or nonexistent. Motor efferences must be continuously reorganized to offer a response adapted to the environment and to the objective of the movement. It is believed that this adaptation, among other things, depends on the ability to form a memory, and on many occasions this memory contributes to motor learning [60]. Basic studies have shown that an inhibition of the somatosensory cortex negated the ability of motor patterns to correct errors.

Therefore, the somatosensory cortex could be critically involved in the updating of memory for motor adaptation [61]. In addition, recent studies have observed that the threshold for evoking motor potentials is lowered by the proximity of a headache episode and that it is dependent on the time elapsed after an attack [62,63]. Thus, it would not be uncommon to hypothesize that patients with chronic headache could clinically present with maladaptive motor alterations derived from the chronification and/or central sensitization process. Unifying the variables and increasing the number and quality of studies could provide more than sufficient evidence to support this hypothesis.

Clinical Implications

There is undoubtedly a large body of literature that supports the relationship between the structures of the cervical spine and the development and even maintenance or perpetuation of headache episodes [64]. The lack of a greater volume of studies in some cases and the low methodological quality in other cases make it difficult to establish firm clinical conclusions that associate cervical musculoskeletal variables with headaches, except in the case of FHP, which should be considered in the exploration and treatment of this type of patient in their transformed or persistent forms. In addition, future studies should consider the objective examination of other physical variables commonly examined in clinical practice such as basal muscle tone and all these physical characteristics in patients with trigeminal-autonomic cephalalgias and other primary headaches.

This systematic review and meta-analysis strongly recommends that future research should consider the possibility of developing longitudinal designs that allow causal relationships to be established, such as risk or protection factors. Therefore, our proposal for future studies is that more work of high methodological quality should be performed, in which the scientific contribution and its transfer to the clinic take precedence over other publication interests.

Looking at Table 1, you can see that sample size is the weakest point. In this line, to avoid risk of bias, further studies should generate a good methodology to establish their sample size.

Limitations

The present study has several limitations. First, no further meta-analysis could be performed due to the limited number of studies currently available (a minimum of three recommended for each meta-analysis). Another limitation is that some variables had been evaluated using different instruments, including analog and digital versions, for example, in the case of FHP. The ideal would be the ability to unify both the units of measurement and the evaluation instruments to facilitate the interpretation of the data obtained. Although the instruments used in the cervical physical examination of these studies are commonly used in clinical practice, we cannot miss the opportunity to point out that the interexaminer variability in the results shown by the CROM to assess the FHP and the manual examination to examine the passive joint motion are high and therefore may be a limitation in terms of obtaining conclusive results [65,66].

On the other hand, although the search covered all the observational designs, only cross-sectional studies were found that met our selection criteria. This situation limits the conclusions of the work, given that it does not allow establishing a causal relationship between the study variables. Regarding meta-analyses that compare CPH with asymptomatic individuals, one study had shown very large effect sizes compared with the other studies. Therefore, this analysis should be taken with caution because it could have influenced the result. Again, the results related to myofascial trigger points were evaluated manually and should be considered with caution. Perhaps, to objectify the measure, it would be more interesting to use standardized measures that ensure greater reliability. Finally, the fact that some studies were only conducted with women and others with greater numbers of men in the sample slightly distorts the reality of this condition, in which the ratio of women to men is ∼3:1 worldwide in migraines and CTTH [6].

Conclusion

In conclusion, this meta-analysis concludes that there is moderate to strong evidence that patients with CPH present greater FHP than the asymptomatic population. In addition, there is moderate evidence that patients with CPH present greater FHP than patients with EPH.

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