Analysis of Head Posture and Activation of the Cervical Neck Extensors During a Low-Load Task in Women With Chronic Migraine and Healthy Participants

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Abstract

Objective: The purpose of this study was to investigate the correlation between head and neck posture and superficial neck flexor and extensor activity during performance of the craniocervical flexion test (CCFT) in women with migraine and healthy controls.
Methods: Fifty-two women with episodic migraine, 16 with chronic migraine, and 23 healthy controls participated. Head and neck posture were determined by assessing the craniovertebral (CV) angle and cervical lordosis angle. Surface electromyography signals were recorded bilaterally from sternocleidomastoid, anterior scalene, splenius capitis, and upper trapezius muscles as participants performed the CCFT. Differences in electromyogram activity and posture among groups were compared with analyses of variance. Correlations between posture and electromyogram activity were analyzed with the Pearson correlation coefficient.
Results: Both migraine groups had a significant increase in splenius capitis muscle activity, when acting as an antagonist, at the last stage of CCFT (F = 4.687; $P = .012$) compared with controls. No differences among groups were observed for head and neck posture. No significant correlation was found in the episodic migraine group. Moderate correlations between the CV angle and upper trapezius activity at the majority stages of the CCFT ($-0.61 < r < -0.65$, all $P < .05$) were observed within the chronic migraine group: the more extended the head posture, the higher the activity of the upper trapezius muscle. The CV angle also was correlated with upper trapezius muscle activity at the first stage of the CCFT and with splenius capitis muscle activity at the last stages ($-0.42 < r < -0.52$; $P < .05$).
Conclusion: An extended (forward) head posture was moderately correlated with an increased in electrical activity of superficial neck extensor muscles, particularly the upper trapezius, when acting as an antagonist, during the performance of the CCFT in women with chronic but not episodic migraine. (J Manipulative Physiol Ther 2019;xx:1-9)
Key Indexing Terms: *Migraine Disorders; Posture; Electromyography*

Introduction

Migraine is a disabling condition with a significant impact on occupational and personal activities.[1-3] Among the several factors that can influence the migraine clinical picture, neck pain has been found to be an important one. Neck pain is highly prevalent in individuals with migraine

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(up to 80%), its presence may delay acute migraine treatment, and higher neck-related disability also is associated with migraine chronification.[4-7] The association between migraine and neck symptoms is attributed to afferent convergences within the trigemino-cervical nucleus caudalis that is sensitized in migraine.[8]

Patients with migraine presenting neck pain also may display altered patterns of cervical neuromuscular activation.[9] Changes in neuromuscular control as increased antagonist coactivation during maximal isometric neck muscles and increased activity of superficial cervical extensors during the craniocervical flexion test (CCFT) recently have been observed in migraineurs.[10-12] That no differences exist in muscle activation of superficial neck flexors during CCFT performance[13,14] suggests that changes in motor performance in participants with migraine may be distinct from those expected for primary neck disorders.[15]

Controversy regarding the presence of altered head and neck posture in participants with migraine deals with what pattern of alteration should be expected. In fact, some studies have reported that migraine patients exhibit further forward head posture compared with healthy people, whereas others did not find such differences.[13,16-18] However, regardless of whether individuals with migraine exhibit an altered or normal posture, it is reasonable that altered head or neck posture can alter neck muscle function, for example, because of changes in muscle fiber length. In such a scenario, Cagnie et al[19] found that the head posture of healthy participants did not significantly correlate with sternocleidomastoid (SCM) activity during the performance of CCFT. However, there is no available data regarding this correlation in people with migraine and even more the correlation of head and neck posture with activation activity of other neck muscles.

Therefore, the aim of the current study was to investigate the correlation between head and neck posture and superficial cervical flexor (SCM, anterior scalene) and extensor (splenius capitis, upper trapezius) activity during performance of CCFT and to determine if there are differences in the correlations between individuals with migraine and healthy controls. We hypothesized that forward head posture will be correlated with higher activity of the cervical flexor and extensor muscles in participants with migraine but not in healthy participants.

Methods

Sample

Women with migraine who are between 18 and 60 years of age were recruited from the Neurology Department Hospital Rey Juan Carlos in Madrid, Spain from November 2014 to October 2015. Participants were diagnosed according to the International Classification of Headache Disorders criteria, third edition (2013) down to third-digit level (code 1.1, 1.3) by a neurologist expert in headaches.[2] Migraine features including location, onset of migraine (years), the frequency (days/month) and intensity of migraine (numerical pain rate scale, 0-10), headache-family history, and medication intake were collected. Exclusion criteria included any of the following: (1) other primary or secondary headaches, including medication overuse headache according to the International Classification of Headache Disorders, third edition criteria; (2) history of neck/head trauma; (3) pregnancy; (4) any other medical (eg, rheumatoid arthritis, lupus erythematous) or neurological (eg, stroke, trigeminal neuralgia) condition; (5) diagnosis of fibromyalgia syndrome; or (6) anesthetic blocks within the past 6 months. All participants signed the informed consent form before their inclusion in the study. The local ethics committee of Hospital Rey Juan Carlos (HRJ 07/14) approved the study design.

Further, a comparable healthy control group without headache history and no headache attack during the previous year also was recruited. Exclusion criteria for the control group were the same as the migraine groups. The evaluation was held when all patients were headache-free, and when 1 week had elapsed since the last migraine attack to avoid migraine-related allodynia. In those patients with chronic migraine, evaluation was conducted at least 3 days after a migraine attack. A clinician blinded to the participant's condition assessed all outcomes.

Head and Neck Posture

The head/neck posture was evaluated by a profile photograph of the cervical spine. Anatomical references were marked by adhesive markers fixed on the occipital bone and the spinous processes of the fourth and seventh cervical vertebrae.[20,21] Vertical reference was provided by a metal plumb line positioned 33 cm from participants. All photographs were obtained by the same technician using a digital camera with a lens of 23 mm (Samsung Lens WB350F) (Samsung, London, England) positioned on a tripod at a distance of 4 m from the participant and adjusted according to the participant's height.

Volunteers were photographed in standing upright and sitting positions without shoes. They were instructed to keep their habitual/comfortable position with their arms alongside the body and the head in a natural relaxed position looking forward.[22] For the standing upright position, they were asked to keep their feet at a comfortable distance apart, and the camera lens center was placed at half of the participant's height.[17] For the sitting position, the camera lens center was placed at the same distance of the height between the ground and the participant's acromioclavicular joint.[18]

Photographs were analyzed using the CorelDraw X7 software (Corel, Ottawa, Ontario, Canada). Head posture

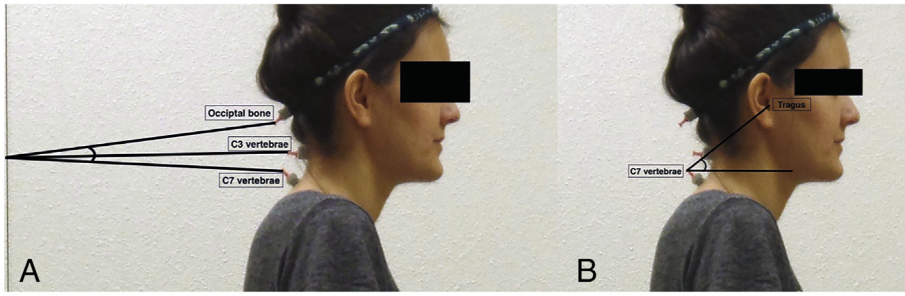

Fig 1. *Assessment of the craniovertebral (A) and cervical lordosis (B) angles.*

was assessed by calculating the craniovertebral (CV) angle, which is determined by the angle between the horizontal line and the line traced from the tragus to the spinous process of C7: the smaller the CV angle, the higher the forward head posture.[21] Neck posture was assessed by determining the cervical lordosis angle. First, a horizontal line was traced from the C4 to the plumb line, and then 2 lines were traced converging to the first, one from occipital bone and other from the C7 vertebra. The angle formed at the intersection of these 2 last lines determines the lordosis angle (Fig 1). Lower lordosis angles reflect higher cervical lordosis curvature.[17,23]

Electromyography Acquisition and Processing

Bipolar surface electrodes were positioned 22 mm apart (Ambu Blue Sensor N-50-K/25) after gentle skin abrasion using abrasive paste and shaving when necessary. Electrodes were placed at the following locations: (1) the SCM muscle: over the muscle belly at one-third the distance from the sternal notch to the mastoid process orientated in the direction of the line that joins these 2 structures[24]; (2) the scalene muscle: over the muscle belly in the direction of fibers running parallel to the lateral boarder of the clavicular portion of the SCM muscle at the same level of the SCM electrode[24]; (3) the splenius capitis muscle: over the muscle belly at the C2-C3 level between the uppermost parts of the SCM and upper trapezius muscles; and[25] (4) the upper trapezius muscle: median point of the distance between the C7 spinal process and acromion.[25] A ground electrode was placed around the participant's wrist.

Myoelectric signals were acquired and amplified by 5000 (EMG16, 16-channel amplifier, LISiN-OT Bioelettronica, Torino, Italy), filtered (-3 dB bandwidth, 10-450 Hz), sampled at 2048 Hz, and converted to 12-bit digital samples. Raw signals were band-filtered a 20-400 Hz (fourth-order Butterworth), and the average root mean square (RMS) was calculated from each 10-second contraction by a customized MATLAB code (The MathWorks, Natick, Massachusetts). Electrical activity was normalized by the maximum RMS during the reference voluntary contraction and expressed as percentage. Reference activities consisted of head lift for superficial neck flexors, and head extension with manual resistance for neck extensors since submaximal normalization has been demonstrated to reduce the variability and is considered to be more acceptable in patients with pain than maximal contraction normalization procedure.[26] Both contractions were performed with participants in a supine position, sustained for 10 seconds and repeated 2× after the CCFT performance. The average from 2 repetitions of left and right neck muscle RMS values was used in the analysis.

CCFT

The CCFT is commonly applied to determine deep neck flexor muscle performance during a low-load task with 5 progressive stages (22 to 30 mmHg) guided by a pressure biofeedback unit (PBU; Stabilizer, Chattanooga Group Inc) (Chattanooga Group Inc, Hixson, Tennessee).[27] An increase in the activity of superficial cervical flexors, that is, SCM and anterior scalene, is considered a consequence of deficient function of deep cervical flexors, that is, longus colli and longus cervicis muscles.[28]

Volunteers were positioned in supine, with the head and neck in neutral, and the PBU was placed at the suboccipital area behind the participant's neck. The initial PBU's inflation pressure was 20 mmHg, and a progressive incremental of a 2-mmHg scale was applied. Habituation with the test was performed first: participants were asked to perform a gentle head-nodding action of craniocervical flexion and discouraged to use compensation strategies, such as head lift, head extension, or opening the mouth. At this phase, participants needed to reach the target level and return to the neutral position. To acquire the myoelectrical signal, each stage target was maintained for 10 seconds and repeated 2× with a 30-second resting interval between them.

Statistical Analysis

Data were summarized by means, standard deviation, or 95% CI. The normal distribution was checked by normal

Table 1. *Demographic and Clinical Pain Features of Migraine and Healthy Control Groups*

	Healthy Controls (n = 23)	Episodic Migraine (n = 52)	Chronic Migraine (n = 16)
Age (y)	44 (39-49)	42 (38-46)	44 (37-51)
Body mass index (kg/cm^2)	22.7 (21.5-24.3)	23.4 (22.4-24.4)	25.5 (22.5-28.4)
Migraine frequency (d/mo) [a]	———	6.2 (5.1-7.13)	21.9 (18.6-25.1)
Migraine intensity (NPRS; 0-10)	———	8.2 (7.6-8.7)	8.0 (6.8-9.1)
Years with migraine	———	18.3 (14.7-22.0)	24.1 (15.3-33.0)
Neck pain, n (%)	7 (30)	51 (98)	15 (94)
Years with neck pain	7.3 (1.6-13.0)	10.3 (6.8-13.8)	13.9 (5.5-22.3)
Neck pain intensity (NPRS, 0-10)	4.6 (2.7-6.4)	5.3 (4.5-6.1)	6.6 (5.1-8.0)

NPRS, Numeric Pain Rating Scale.
All data are expressed as mean and CI, otherwise is indicated.
[a] Differences between episodic and chronic migraine groups ($P < .001$).

probability plots, comparing residuals versus theoretical quartiles of a standard normal distribution and confirmed by the Shapiro-Wilk test. All quantitative variables demonstrate a normal distribution. Sample characteristics and normalized RMS were compared among the groups (chronic migraine, episodic migraine, or healthy controls) by an analysis of variance applying the Bonferroni test as a post hoc, since all assumptions to run this analysis (type of variables, independent groups, independent observations, no significant outlier, normal distribution of the variables, homogeneity of variance) were met. Pairwise comparison between episodic and chronic migraine groups regarding migraine clinical characteristics were performed by Student's *t* test, and χ-square was applied to compare the proportion of the neck pain presence among 3 groups. Correlations among the CV, lordosis angle, and normalized RMS for each neck muscle at all CCFT stages were calculated by the Pearson correlation coefficient (r) separately for chronic migraine, episodic migraine, and healthy controls. Correlations were classified as weak when $r < 0.3$, as moderated when r ranges from 0.3 to 0.7, and as strong when $r > 0.7$. All analysis was performed using the SPSS 20.0 software (IBM Corp, Armonk, New York) and adopting a significance level of .05.

Results

From 90 eligible participants with migraine who agreed to participated, 22 were excluded for the following reasons: comorbid headaches (n = 17), receiving anesthetic block (n = 3), or diagnosis of fibromyalgia (n = 2). Finally, 68 women, mean age: 43 ± 11 years, with migraine without aura were included. Fifty-two women (76%), mean age: 42 ± 12 years, were classified as episodic migraine whereas the remaining 16 (24%), mean age: 44 ± 13, were classified as chronic migraine. In addition, a comparable group of 23 healthy women, age: 44 ± 12 years, also was included. No significant differences in demographic variables were observed among the 3 groups, except for the presence of neck pain ($X^2 = 48.222$; $P < .001$), which was more frequent in both migraine groups. Further, significant difference also was found for migraine frequency ($t = 9.845$; $P < .001$) because women with chronic migraine experienced a higher frequency of migraine attacks (mean difference: 15.7, 95% CI 12.4-19.0). Table 1 shows the clinical and demographic data of each group.

There were no significant differences in head posture in either sitting ($F = 1.388$; $P = .255$) or standing ($F = 1.675$; $P = .193$) positions among individuals with episodic or chronic migraine and healthy controls. Similarly, no significant differences were found among groups for cervical lordosis in sitting ($F = 1.659$; $P = .196$) and standing upright ($F = 0.684$; $P = .508$) positions (Fig 2).

The analysis of variance revealed that both migraine groups exhibited increased activity of the splenius capitis muscle, when acting as an antagonist ($F = 4.687$; $P = .012$), as compared with healthy controls at a CCFT stage of 30 mmHg (episodic migraine vs healthy controls: 9.9, 95% CI 1.5-18.3; chronic migraine vs healthy controls: 11.0, 95% CI 3.0-20.0). No further differences were observed on neck muscle activity during all stages of CCFT (Fig 3).

No significant correlation was observed between CV or cervical lordosis angles and activity of superficial neck flexor or extensor muscles within the episodic migraine group (Table 2). In the chronic migraine group, the CV angle in sitting position showed significant negative moderate correlations with normalized RMS of the upper trapezius muscle at all CCFT stages ($-0.61 < r < -0.65$, all $P < .05$). Further, the CV angle within the standing position also showed significant and negative correlations with

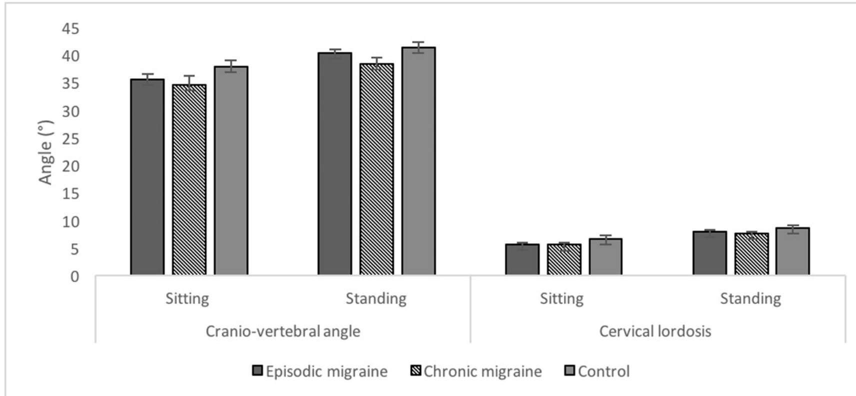

Fig 2. *Assessment of head and neck posture (mean and standard error) in women with migraine (episodic or chronic) and healthy women.*

normalized RMS of the upper trapezius muscle at 22, 24, 28, and 30 mmHg stages (-0.50 < r < -0.56, all *P* < .05): the lower the CV, that is, the greater the forward head posture in either sitting or standing positions, the higher the activity of the upper trapezius muscle, acting as an antagonist, during the majority stages of the CCFT (Table 2). The cervical lordosis angle did not exhibit any significant correlation with activity of the superficial neck flexors or extensor muscles within the chronic migraine group (Table 2).

In the healthy control group, significant moderate and negative correlations were observed between the CV angle and upper trapezius muscle activity in the first stage (r = -0.44; *P* = .040) and with splenius capitis muscle activity in the last 3 stages of the CCFT (-0.42 < r < -0.52; all *P* < .05): again, as the head becomes more forward, the superficial extensor activity, when acting as antagonists, is higher (Table 2). Similarly, the cervical lordosis angle did not exhibit any significant correlation with the activity of superficial neck flexors or extensors within the chronic migraine group (Table 2).

Discussion

The current study found that an extended (forward) head posture was moderately correlated with an increase in electrical activity of superficial neck extensor muscles, particularly the upper trapezius, when acting as an antagonist, during the performance of the CCFT in women with chronic but not episodic migraine. This correlation also was observed in healthy controls without a history of migraine. Current results reject the main hypothesis because we expected this association in both migraine groups, but not within the healthy control group.

We did not find differences in superficial neck flexor activity during the CCFT, which is in agreement with previous data.[12-14] Further, women with migraine displayed significantly increased activity of the splenius capitis muscle, when acting as an antagonist, during the last stage of the CCFT. This agrees with the hypothesis that motor control changes seen in migraineurs do not match the common pattern of activation expected for individuals with primary neck pain, which is mainly characterized by increased activity of the superficial neck flexors.[12,15] This is particularly relevant because most of our sample of women with migraine also reported concomitant neck pain. In addition, we also did not observe differences in head/neck posture between women with migraine and healthy women, again in agreement with previous studies.[13,29]

To the best of the authors' knowledge, there is only 1 previous study analyzing the correlation of head posture and neck muscle activity during performance of CCFT.[19] This study was conducted in healthy participants, and no significant correlations between head posture and SCM muscle activity were demonstrated.[19] Our results agree with this study because we also did not find any correlation between head or neck posture and the activity of superficial neck flexors, that is, SCM and anterior scalene, in healthy people or patients with migraine. This may be related to the fact that individuals with migraine did not display altered activity of the superficial neck flexors compared with healthy people. We do not know if a correlation between these variables may be present in patients with primary neck pain; but current data suggest that at least for migraineurs with concomitant neck pain, the lack of significant correlation between head/neck posture and superficial cervical flexor activity still occurs.

The novelty of our study was to add the analysis of superficial neck extensors acting as antagonists during the CCFT. In our study, women migraine, either episodic or chronic, exhibited increased activity of the splenius capitis, that is, a superficial neck extensor, during the CCFT compared with healthy controls. Our findings are similar to those previously reported in individuals with chronic tension-type headache.[30] Some experimental human pain studies had previously shown that pain induces

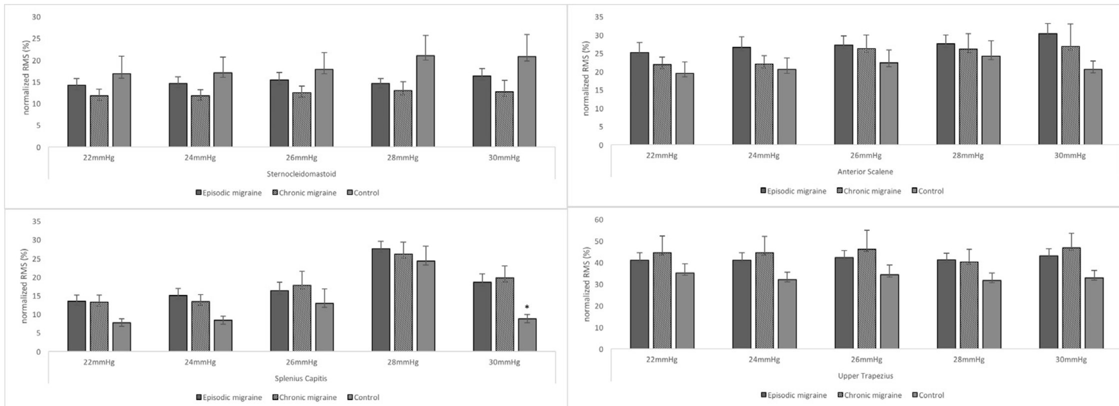

Fig 3. *Normalized RMS of neck muscles during the 5 stages of craniocervical flexion test for episodic migraine (n = 52), chronic migraine (n = 16), and healthy controls (n = 23). *Differences between episodic and chronic migraine (P < .05).* RMS, *root mean square.*

reorganization of the motor strategy by reducing the activity of agonist muscles and increasing activity of antagonist muscles,[31] which would lead to a redistribution of the activity within and between muscles.[32]

We also found moderate correlations between head posture and superficial neck extensor muscles, particularly the upper portion of the trapezius, suggesting that a more extended (forward) head posture was correlated with increased activity in the upper trapezius, when acting as an antagonist, in women with chronic but not episodic migraine during the performance of the CCFT. Similarly, a more extended head posture also was correlated with increased activity of splenius capitis and upper trapezius muscles in healthy participant. Our findings differ from those previously reported by Lee et al.[33] This study correlated a forward head posture with reduced activity of neck muscles during head protraction and retraction movements. It is possible that differences in the task, differences in patient populations, or the method determining forward head posture may justify discrepancies between studies. It is also plausible that this correlation between forward head posture and increased activity of some cervical extensors, when acting as antagonists, may be related to the presence of neck pain in our sample of migraineurs; however, this seems unlikely because the correlations were observed only within the chronic migraine group, but not in the episodic group, when both groups exhibited a similar prevalence of concomitant neck pain. Similarly, that a correlation also was found within the healthy control group would not support a potential role of neck pain in our results. Future studies are needed to further determine the role of neck pain in the correlation between head posture and cervical musculature activity.

Determining the mechanisms underlying the correlation between head posture and an increased activity of superficial neck extensors is beyond the scope of the current study; however, current results have some potential implications for clinical practice in relation to assessment of the cervical spine for applying better therapeutic interventions for patients with migraine. For instance, proper head posture should be achieved during the therapeutic exercises for avoiding overactivation of the superficial neck extensors. Finally, the application of manual therapies for decreasing muscle activity of the upper trapezius muscle also can be applied before starting the exercise program. Nevertheless, because we did not find differences in head and neck posture between women with migraine and healthy women and no correlation was shown between head posture and splenius capitis muscle activity during the CCFT in participants with migraine, we should not attribute the higher activation of the splenius capitis muscle, when acting as antagonist, observed in both migraine groups to differences in posture. This motor control change observed in participants with migraine may be a distinct adaptation as a consequence of the imbalance of the central pain modulation or even may be a consequence of other factors not included in the current study as previously suggested.[12] We proposed that head and neck posture may act as a contributing factor for muscle coactivation.

Limitations

We included women recruited from a tertiary headache center. Although migraine is more prevalent in women, we do not know if the same results would be observed in community-based populations or in men. Second, it is also possible that the study was slightly underpowered for detecting moderate correlations between the variables because of the sample size. The results of this study could be used for determining proper sample sizes in future studies. Finally, there are other aspects, such as fear of movement, that have not been included in this study that could be correlated to neck muscle activity.

Table 2. *Correlation Between Head or Neck Posture According to CV and CL Angles and Neck Muscle Activity During the Performance of the CCFT in Episodic Migraine, Chronic Migraine, and Healthy Participants*

		Episodic Migraine (n = 52)				Chronic Migraine (n = 16)				Healthy Controls (n = 23)			
		CV		CL		CV		CL		CV		CL	
CCFT	RMS	Seated	Upright	Seated	Upright	Seated	Upright	Seated	Upright	Seated	Upright	Seated	Upright
22 mmHg	SCM	0.15	0.22	0.16	0.17	-0.45	-0.14	-0.01	-0.24	0.20	0.08	0.21	-0.07
	Anterior scalene	0.04	0.07	0.15	0.03	-0.24	-0.32	-0.16	-0.30	0.21	0.16	0.25	0.09
	Splenius capitis	0.12	0.16	-0.12	0.03	-0.23	-0.10	-0.02	-0.24	-0.28	0.02	0.02	0.36
	Upper trapezius	-0.16	0.04	-0.16	-0.18	-0.63 [b]	-0.50 [a]	-0.28	0,08	-0.44 [a]	-0.27	0.01	0.12
24 mmHg	SCM	0.02	0.09	0.12	0.08	-0.47	-0.28	0,01	-0.28	0.23	0.07	0.22	-0.08
	Anterior scalene	-0.10	-0.05	0.03	-0.04	-0.47	-0.49	-0.06	-0.29	0.13	0.13	0.17	0.11
	Splenius capitis	0.11	0.14	-0.12	0.01	-0.23	-0.09	0.01	-0.21	-0.20	0.12	0.18	0.05
	Upper trapezius	-0.22	-0.03	-0.17	-0.21	-0.63 [b]	-0.51 [a]	-0.28	0.09	-0.25	0.14	0.28	0.40
26 mmHg	SCM	0.06	0.11	0.05	-0.07	-0.47	-0.30	-0.17	-0.28	0.25	0.15	0.29	-0.004
	Anterior scalene	0.03	0.06	0.05	-0.06	-0.16	-0.28	-0.18	-0.25	0.07	0.17	0.23	0.25
	Splenius capitis	0.11	0.11	-0.12	-0.08	-0.23	-0.06	-0.01	-0.14	-0.42	-0.51 [a]	-0.23	-0.09
	Upper trapezius	-0.17	-0.01	-0.18	-0.21	-0.61 [a]	-0.49	-0.25	0.11	-0.41	-0.25	0.04	0.14
28 mmHg	SCM	0.02	0.04	-0.02	-0.20	-0.43	-0.35	-0.23	-0.34	0.24	-0.02	0.10	-0.20
	Anterior scalene	-0.05	-0.02	-0.03	-0.21	-0,20	-0.29	-0.03	-0.13	0.14	-0.01	0.03	-0.09
	Splenius capitis	0.11	0.07	-0.14	-0.13	-0.19	-0.04	0.03	-0.08	-0.42 [c]	-0.52 [a]	-0.24	-0.09
	Upper trapezius	-0.15	0.01	-0.16	-0.21	-0.65 [b]	-0.53 [a]	-0.32	0.02	-0.22	0.18	0.28	0.38
30 mmHg	SCM	-0.01	0.08	0.04	-0.05	-0.16	-0.12	-0.13	-0.08	0.28	0.01	0.13	-0.18
	Anterior scalene	-0.07	-0.05	-0.06	-0.22	-0.05	-0.15	-0.08	-0.09	0.13	0.13	0.15	0.17
	Splenius capitis	0.14	0.10	-0.14	-0.13	-0.07	0.05	0.12	0.11	-0.49 [a]	-0.21	-0.14	0.41
	Upper trapezius	-0.24	-0.14	-0.18	-0.25	-0.64 [b]	-0.56 [a]	-0.30	-0.01	-0.19	0.20	0.29	0.38

CCFT, Craniocervical Flexion Test; *CL*, cervical lordosis; *CV*, craniovertebral; *RMS*, root mean square; *SCM*, sternocleidomastoid.
[a] $P < .05$.
[b] $P < .01$.

Conclusion

This study found that women with migraine exhibited increased activation of the splenius capitis muscle, acting as an antagonist during the performance of CCFT, compared with healthy women. No significant differences in head or neck posture were found between patients and controls. An extended (forward) head posture was correlated with an increase in electrical activity of superficial neck extensor muscles, particularly the upper trapezius muscle, when acting as an antagonist, during the performance of the CCFT in women with chronic but not episodic migraine. This correlation also was observed in healthy controls without a history of headache.

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The first author received a grant from The São Paulo Research Foundation (process number 2012/ 22245-2). No conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): L.L.F., G.N.F., T.C.C., M.P.-C., C.O.-B., J.G.S., D.B.G., C.F.-d.-l.-P.
Design (planned the methods to generate the results): L.L.F., G.N.F., T.C.C., M.P.-C., C.O.-B., J.G.S., D.B.G.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): C.F.-d.-l.-P.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): L.L.F., G.N.F., T.C.C., M.P.-C.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): L.L.F., G.N.F., T.C.C., M.P.-C., C.O.-B., J.G.S., D.B.G.
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Practical Applications

- Women with migraine exhibited increased activation of the splenius capitis muscle, acting as an antagonist during the performance of CCFT, compared with healthy women.
- No significant differences in head and/or neck posture were observed between patients and controls.
- A forward head posture was correlated with an increase in electrical activity of superficial neck extensor muscles when acting as antagonists, during the performance of the CCFT in women with chronic but not episodic migraine.

References

1. Buse DC, Lipton RB. Global perspectives on the burden of episodic and chronic migraine. *Cephalalgia.* 2013;33(11): 885-890.
2. The International Classification of Headache Disorders, 3rd edition (beta version). *Cephalalgia.* 2013;33(9):629-808.
3. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2012;380(9859):2163-2196.
4. Ashina S, Bendtsen L, Lyngberg AC, Lipton RB, Hajiyeva N, Jensen R. Prevalence of neck pain in migraine and tension-type headache: a population study. *Cephalalgia.* 2015;35(3): 211-219.
5. Fernández-de-las-Peñas C, Hernández-Barrera V, Carrasco-Garrido P, et al. Population-based study of migraine in Spanish adults: relation to socio-demographic factors, lifestyle and co-morbidity with other conditions. *J Headache Pain.* 2010;11(2):97-104.
6. Calhoun AH, Ford S. Double-blind, placebo-controlled, crossover study of early-intervention with sumatriptan 85/ naproxen sodium 500 in (truly) episodic migraine: what's neck pain got to do with it? *Postgrad Med.* 2014;126(2): 86-90.
7. Ford S, Calhoun A, Kahn K, Mann J, Finkel A. Predictors of disability in migraineurs referred to a tertiary clinic: neck pain, headache characteristics, and coping behaviors. *Headache.* 2008;48(4):523-528.
8. Robertson B, Morris ME. The role of cervical dysfunction in migraine: a systematic review. *Cephalalgia.* 2008;28(5): 474-483.
9. Hodges PW, Tucker K. Moving differently in pain: a new theory to explain the adaptation to pain. *Pain.* 2011;152 (3 Suppl):S90-S98.
10. Oksanen A, Pöyhönen T, Ylinen JJ, et al. Force production and EMG activity of neck muscles in adolescent headache. *Disabil Rehabil.* 2008;30(3):231-239.
11. Florencio LL, de Oliveira AS, Carvalho GF, et al. Cervical muscle strength and muscle coactivation during isometric contractions in patients with migraine: a cross-sectional study. *Headache.* 2015;55(10):1312-1322.
12. Florencio LL, Oliveira AS, Lemos TW, et al. Patients with chronic, but not episodic, migraine display altered activity of their neck extensor muscles. *J Electromyogr Kinesiol.* 2016; 30:66-72.
13. Zito G, Jull G, Story I. Clinical tests of musculoskeletal dysfunction in the diagnosis of cervicogenic headache. *Man Ther.* 2006;11(2):118-129.
14. Jull G, Amiri M, Bullock-Saxton J, Darnell R, Lander C. Cervical musculoskeletal impairment in frequent intermittent headache. Part 1: subjects with single headaches. *Cephalalgia.* 2007;27(7):793-802.
15. O'Leary S, Falla D, Elliott JM, Jull G. Muscle dysfunction in cervical spine pain: implications for assessment and management. *J Orthop Sports Phys Ther.* 2009;39(5):324-333.
16. Tali D, Menahem I, Vered E, Kalichman L. Upper cervical mobility, posture and myofascial trigger points in subjects with episodic migraine: case-control study. *J Bodyw Mov Ther.* 2014;18(4):569-575.
17. Ferreira MC, Bevilaqua-Grossi D, Dach FE, Speciali JG, Goncalves MC, Chaves TC. Body posture changes in women with migraine with or without temporomandibular disorders. *Brazilian J Phys Ther.* 2014;18(1):19-29.
18. Fernández-de-las-Peñas C, Cuadrado ML, Pareja JA. Myofascial trigger points, neck mobility and forward head posture in unilateral migraine. *Cephalalgia.* 2006;26(9):1061-1070.
19. Cagnie B, Danneels L, Cools A, Dickx N, Cambier D. The influence of breathing type, expiration and cervical posture on the performance of the cranio-cervical flexion test in healthy subjects. *Man Ther.* 2008;13(3):232-238.
20. Gadotti IC, Magee D. Validity of surface markers placement on the cervical spine for craniocervical posture assessment. *Man Ther.* 2013;18(3):243-247.

21. Raine S, Twomey LT. Head and shoulder posture variations in 160 asymptomatic women and men. *Arch Phys Med Rehabil.* 1997;78(11):1215-1223.
22. Lau KT, Cheung KY, Chan kwok B, Chan MH, Lo KY, Wing Chiu TT. Relationships between sagittal postures of thoracic and cervical spine, presence of neck pain, neck pain severity and disability. *Man Ther.* 2010;15(5):457-462.
23. Iunes D, Carvalho L, Oliveira A, Bevilaqua-Grossi D. Craniocervical posture analysis in patients with temporomandibular disorder. *Rev Bras Fis.* 2009;13(1):89-95.
24. Falla D, Dall'Alba P, Rainoldi A, Merletti R, Jull G. Location of innervation zones of sternocleidomastoid and scalene muscles: a basis for clinical and research electromyography applications. *Clin Neurophysiol.* 2002;113(1):57-63.
25. Falla D, Farina D, Dahl MK. Muscle pain induces task-dependent changes in cervical agonist/antagonist activity. *J Appl Physiol.* 2007;102(2):601-609.
26. Allison GT, Fujiwara T. The relationship between EMG median frequency and low frequency band amplitude changes at different levels of muscle capacity. *Clin Biomech.* 2002;17(6):464-469.
27. Jull G, O'Leary SP, Falla DL. Clinical assessment of the deep cervical flexor muscles: the craniocervical flexion test. *J Manipulative Physiol Ther.* 2008;31(7):525-533.
28. Falla D, Jull G, Dall'Alba P, Rainoldi A, Merletti R. An electromyographic analysis of the deep cervical flexor muscles in performance of craniocervical flexion. *Phys Ther.* 2003;83(10):899-906.
29. Ferracini GN, Dach F, Chaves TC, et al. Cervico-occipital posture in women with migraine: a case-control study. *J Orthop Sports Phys Ther.* 2016;46(4):251-257.
30. Fernández-de-las-Peñas C, Falla D, Arendt-Nielsen L, Farina D. Cervical muscle co-activation in isometric contractions is enhanced in chronic tension-type headache patients. *Cephalalgia.* 2008;28(7):744-751.
31. Graven-Nielsen T, Svensson P, Arendt-Nielsen L. Effects of experimental muscle pain on muscle activity and co-ordination during static and dynamic motor function. *Electroencephalogr Clin Neurophysiol.* 1997;105(2):156-164.
32. Hodges P, Falla D. Interaction between pain and sensorimotor control. In: Jull G, Moore A, Falla D, Lewis J, McCarthy C, Sterling M, eds. *Grieve's Modern Musculoskeletal Physiotherapy*. 4th ed. United Kingdom: Elsevier; 2015.
33. Lee KJ, Han HY, Cheon SH, Park SH, Yong MS. The effect of forward head posture on muscle activity during neck protraction and retraction. *J Phys Ther Sci.* 2015;27(3):977-979.