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Cervical Muscular Endurance Performance in Women With and Without Migraine

An increasing number of studies have reported that individuals with migraine are more likely to present with neck pain[2,4,5,8,16,24-26,36] and cervical dysfunction.[10-12,30] The coexistence of migraine and neck pain is also associated with a greater frequency of migraine attacks,[10,13] a greater susceptibility to chronification,[24,38] and more severe self-reported migraine-related disability.[13] Accordingly, the primary role of physical therapists in the management of migraine may be to recognize, treat, and prevent potential disorders of the musculoskeletal system that may be associated with these patients' headaches.[14]

Strength, endurance, and coordination deficits of the neck musculature are expected findings in patients with neck pain and headache.[3] Although this applies directly to individuals with cervicogenic headache, these deficits may also be present in patients with migraine. A number of studies have reported weakness and altered coordination of the neck musculature in individuals with migraine,[9,11,12,30,32] yet only 2 studies, to our knowledge, have investigated neck flexor endurance.[31,40] Oksanen et al[31] reported no differences in neck flexion holding time between adolescents with migraine and healthy adolescents. This finding seems consistent with the results from Wanderley et al,[40] who reported no increased fatigability of the sternocleidomastoid in adults when compared to healthy controls when performing a 20-second neck flexion isometric contraction.

BACKGROUND: Despite previous evidence, the association between migraines and cervical muscular performance is unclear.

OBJECTIVE: To compare the differences in neck flexor and extensor muscle endurance between women with and without migraine.

METHODS: In this cross-sectional, controlled laboratory study, 26 women with migraine and 26 age-matched women without migraine or headache were assessed using clinical tests of neck flexor and extensor muscle endurance. Holding times were compared between groups using the Mann-Whitney *U* test for independent samples.

RESULTS: Patients with migraine exhibited a lower holding time for both neck extensor endurance ($P = .001$) and neck flexor endurance ($P<.001$) than did the controls. The median neck flexor holding time was 35.0 seconds for the migraine group and 60.5 seconds for the control group. The migraine group held the neck extensor endurance test position for a median of 166.5 seconds compared to 290.5 seconds held by the control group. Both groups reported a similar level of neck pain during the endurance tests ($P>.05$); however, only individuals in the migraine group reported pain referred to the head during testing.

CONCLUSION: Women with migraine demonstrated decreased neck flexor and extensor endurance compared to women without migraine, which may indicate an association between migraine and reduced performance of the neck muscles.
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However, no study has reported on neck muscle endurance in women with migraine, which represents the most prevalent sex and age group affected by migraine.[1] Moreover, there is a lack of information regarding endurance of the neck extensors, the only muscle group with reported weakness in patients with migraine.[11] Therefore, the aim of this study was to compare the endurance of the neck flexors and extensors between women with and without migraine. We hypothesized that women with migraine would present with lower endurance. As a secondary and exploratory objective, we sought to determine the potential influence of neck pain on the tests used in this study; thus, muscle endurance results

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are described using stratification by both self-reported history of neck pain and neck pain during these tests.

METHODS

Participants

Women between 18 and 55 years of age with a history of migraine were recruited from the headache clinic at a university-based hospital from September 2016 to February 2018. The inclusion criteria were (1) a diagnosis of migraine by a neurologist with 13 years of experience in headaches, (2) diagnosis made according to the beta version of the third edition of the *International Classification of Headache Disorders*,[20] and (3) a frequency of at least 3 migraine attacks per month for the past 3 months. Age-matched (within 5 years) women with no history of headache, were recruited from the local community and by social media advertisements to participate in the control group.

The exclusion criteria for all participants were (1) other primary or secondary headache diagnoses, (2) a history of overuse of headache medication, according to *International Classification of Headache Disorders* recommendations,[20] (3) a history of head and/or neck trauma, (4) current pregnancy, (5) history of cancer, (6) the use of an anesthetic block within the past 3 months, (7) a history of cervical disc herniation, and (8) spinal articular degenerative disease, as confirmed by the medical records from the hospital and/or by the participant's report. All participants gave written informed consent, according to the Ethics Committee of the Ribeirão Preto Medical School (process number 1100/2017), and their rights were protected.

The sample-size estimation was based on data from a pilot study with 15 female participants in each group. Using data for the neck extensors, 26 participants in each group were required, based on the following parameters: effect size of 0.71, derived from the mean ± SD holding times of 313.5 ± 124.2 seconds for controls and 221.6 ± 135.4 seconds for the migraine group; a power of 80%; and a level of significance of .05. Sample calculations were performed using G*Power Version 3.1.9.2 (Heinrich-Heine Universität, Düsseldorf, Germany).

Procedures

Participants' demographics included data on age, weight, and height. They were asked to report the characteristics of their migraines, such as their frequency (number of days with migraine per month), years suffering from migraine, and the intensity of migraines on an 11-point numeric pain-rating scale.[22] The same questions were asked regarding the characteristics of neck pain.

Muscle endurance tests for the neck flexors and extensors were performed by an examiner blinded to the participant's group allocation. Testing was performed consistent with the protocol proposed by Edmondston et al.[6,7] Reported intrarater reliability for testing of the neck flexors and extensors varied from 0.71 to 0.93 and from 0.73 to 0.85, respectively.[7,28] Tests were only performed once to prevent pain exacerbation. The holding time for each test was measured in seconds using a manual stopwatch.

The neck extensor endurance test was performed with participants in a prone position, with their head over the removable support of the plinth and their arms alongside their body. Nonelastic straps at the level of the sixth thoracic vertebra and posterior superior iliac spines were used to stabilize the participant's trunk. A separate strap was used around the participant's head to suspend a 2-kg weight approximately 30 cm above the floor (**FIGURE 1**). The participant's head was positioned in a neutral horizontal plane, with a gentle chin tuck, and the test was started when the examiner removed the support from the participant's head. The participants were instructed to keep their head in the same position, with eyes looking at the floor. The test was concluded when (1) the participant was no longer able to sustain the head position, (2) the head/neck position changed more than 5° for more than 3 seconds, as registered by the CROM device (Performance

FIGURE 1. Position to perform the neck extensor endurance test, with a 2-kg weight and the CROM device (Performance Attainment Associates) to monitor head displacement.

Attainment Associates, Lindstrom, MN), or (3) the participant decided to terminate the test due to neck pain or fatigue. The examiner provided verbal encouragement, such as "Try to maintain your head position" or "Keep up this position," throughout the test.[6,7]

The neck flexor endurance test was performed with participants in a hook-lying position. Nonelastic straps were positioned at the sternum and the anterior superior iliac spines to stabilize the participant's trunk. The examiner placed his hand behind the occiput and instructed the participant to perform craniocervical neck flexion, followed by a gentle lift of the head off the plinth (**FIGURE 2**). The desired position to start the test was a combination of slight head and neck flexion, so as to test both superficial and deep neck flexors, and a distance between the participant's head and the examiner's hand of about 3 cm. Verbal instructions, such as "Tuck your chin in," "Hold your head up," or "Try to keep this position," were given to encourage the participant to maintain the test position. The test was concluded when (1) the participant was unable to maintain the unsupported head position, or (2) the participant decided to terminate the test due to neck pain or fatigue.[6,7]

FIGURE 2. Position to perform the neck flexor endurance test, with the patient in a hook-lying position while performing a combination of upper and lower cervical spine flexion.

Statistical Analysis

Statistical analyses were performed using SPSS Statistics Version 20 (IBM Corporation, Armonk, NY), with the significance level set at $P<.05$. Descriptive statistics were used to characterize the sample and to summarize the results. Data that were normally distributed were presented as mean, SD, and 95% confidence interval. Data without normal distribution were descriptively presented as median and interquartile range. The distribution of dependent variables was verified by histograms and by comparison between residual and theoretical quartiles of a standard normal distribution, and confirmed by the Shapiro-Wilk test.

Demographics were compared between groups using the Student *t* test for independent samples. The proportional distributions of self-reported neck pain and neck pain during the test between groups were compared using the chi-square test or Fisher exact test. However, as no normal distribution could be confirmed for them, holding times for both endurance tests were compared between groups using the Mann-Whitney *U* test.

To determine the potential influence of neck pain on holding time for both tests, the migraine and control groups were stratified by self-reported history of neck pain (the subgroup with a "history of neck pain"). Additionally, a second and independent stratification was performed based on the presence of neck pain during the endurance tests (the subgroup reporting "neck pain during the test"). Based on the low sample sizes, only descriptive data were provided for the above subgroups.

RESULTS

Potential participants with migraine (n = 92) were recruited from the headache center. Sixty-six (72%) were excluded due to a concomitant headache diagnosis, analgesic overuse, or because they had fewer than 3 migraine attacks over the past 3 months. Therefore, 26 participants with migraine (mean ± SD age, 29.8 ± 7.5 years) and 26 controls (age, 28.6 ± 3.7 years) were included in the study. Descriptive data on migraine intensity and frequency are provided in **TABLE 1**. A history of neck pain was reported by 18 individuals (69%) in the migraine group and by 3 individuals (12%) in the control group (χ^2 = 17.972, $P<.001$) (**TABLE 1**).

The migraine group demonstrated a shorter holding time than the control group for both the cervical flexor (U = 132.0, z = −3.771, $P<.001$) and extensor (U = 149.5, z = −3.450, P = .001) muscles (**FIGURE 3**). The median holding times for neck flexion were 35.0 seconds and 60.5 seconds for the migraine and control groups, respectively. The median holding

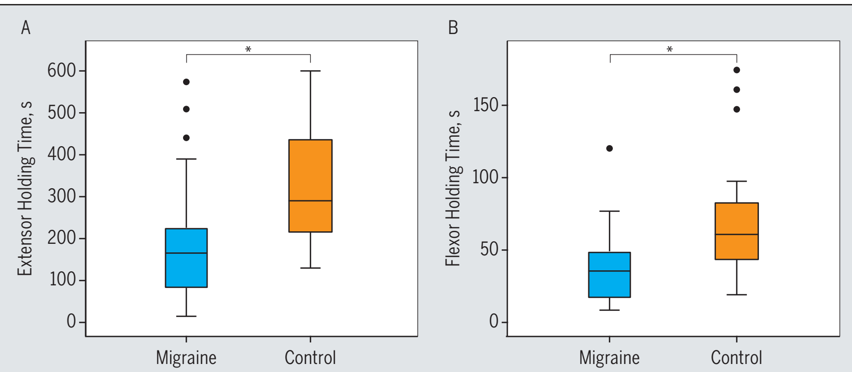

FIGURE 3. (A) Neck extensor and (B) flexor holding times for individuals with migraine (n = 26) and controls (n = 26). In the box plot, horizontal bold lines show the medians, and the box limits indicate the 25th and 75th percentiles. Whiskers represent the upper and lower limits and dots represent the outliers. *$P \leq .001$, obtained from the Mann-Whitney *U* test for independent samples.

times for neck extension were 166.5 seconds and 290.5 seconds for the migraine and control groups, respectively (**FIGURE 3**, **TABLE 2**).

When the data were stratified based on a history of neck pain, muscle endurance was higher in the control group, regardless of a history of neck pain. Those in the control group with a history of neck pain showed lower endurance in both muscle groups (**TABLE 2**). In the group of individuals with migraine, those with a history of neck pain had lower endurance for the neck extensors but, in contrast, slightly higher endurance for the neck flexors (**TABLE 2**).

The proportion of participants who reported neck pain during both endurance tests was similar between the migraine and control groups (flexion test, P = .55; extension test, P = 1.00) (**TABLE 1**). Twenty-seven percent of patients in the control group reported neck pain during neck flexion and 46% reported neck pain during neck extension. Within the migraine group, 39% of patients reported neck pain during neck flexion and 46% during neck extension. In the control group, participants who reported neck pain during the test had a greater holding time for both the extensor and flexor endurance tests than those without neck pain (**TABLE 2**). This contrasts the findings in those with migraine, which indicate a greater holding time for both tests for those who did not report neck pain during the tests (**TABLE 2**). Only individuals in the migraine group reported pain referred to the head during the endurance tests: 27% during neck flexion and 23% during neck extension (**TABLE 1**).

DISCUSSION

THE RESULTS OF THIS STUDY SUGGEST that migraine may be associated with reduced cervical muscle endurance for both the neck flexors and extensors. Neck pain during testing did not appear to affect the results, as similar rates of neck pain and mean neck pain intensity during both endurance tests were reported for both the migraine and control groups.

The current study is, to our knowledge, the first to investigate cervical muscle endurance in women with migraine

TABLE 1 Demographics and Pain Data*

	Migraine Group (n = 26)	Control Group (n = 26)	Mean Difference†	P Value
Age, y	29.8 ± 7.5	28.6 ± 3.7	1.2 (−2.0, 4.5)	.45
BMI, kg/m^2	24.3 ± 4.2	22.7 ± 3.5	1.7 (−0.5, 3.8)	.13
Migraine				
Years with the symptoms	15.9 ± 8.1			
Frequency of attacks, d/mo	9.3 ± 7.9			
Duration, h	31.0 ± 29.3			
Intensity (0-10 NPRS)	8.9 ± 1.1			
History of neck pain‡				
Presence, n (%)	18 (69)	3 (12)		<.001
Years with the symptoms	4.2 ± 3.8	1.7 ± 0.6		
Frequency, d/mo	10.6 ± 6.3	10.0 ± 4.4		
Intensity (0-10 NPRS)	4.7 ± 1.6	6.0 ± 2.0		
Neck flexor test				
Neck pain during the test, n (%)§	10 (39)	7 (27)		.55
Neck pain intensity (0-10 NPRS)‖	3.7 ± 2.3	4.9 ± 2.8		
Pain referred to the head, n (%)‖	7 (27)	0 (0)		
Intensity of pain referred to the head (0-10 NPRS)‖	4.3 ± 2.8	...		
Neck extensor test				
Neck pain during the test, n (%)§	12 (46)	12 (46)		1.00
Neck pain intensity (0-10 NPRS)‖	4.0 ± 2.1	4.6 ± 2.6		
Pain referred to the head, n (%)‖	6 (23)	0 (0)		
Intensity of pain referred to the head (0-10 NPRS)‖	4.3 ± 2.2	....		

Abbreviations: BMI, body mass index; NPRS, numeric pain-rating scale.
**Values are mean ± SD unless otherwise indicated.*
†Values in parentheses are 95% confidence interval.
‡Neck pain characteristics were not compared statistically due to the low number of controls with neck pain (n = 3).
§P value obtained from a chi-square test.
‖Pain characteristics during the test were not compared statistically due to the low number in both groups.

and adds to existing knowledge about the profile of cervical spine muscle impairments in this population. The assessment protocol used in the current study is reliable,[7] easily reproduced in clinical practice, and does not require specific or expensive instruments.[39] Considering that most daily activities are related to sustained posture of the cervical spine, this reduced muscle endurance would likely contribute to neck-related disability and pain.[10]

Our results differ from those reported in previous studies. The median holding time for the neck flexors in our control group (60.5 seconds) was lower than the mean holding time previously reported for healthy girls (70.3 seconds).[31] Similarly, in the migraine group, the median holding time found in the current study (35.0 seconds) was lower than the previously reported mean holding time for girls with migraine (54.1 seconds).[31] This lower holding time was likely due, in part, to the different methods used to assess neck flexor endurance, as Oksanen et al[31] tested endurance with participants performing cervical spine forward flexion while jutting out the chin.

Differences between studies may also reflect age-related differences,[18] the mean ages being 17 and 29 years for the previous[31] and current studies, respectively. However, the most notable difference is that Oksanen et al[31] reported no difference in neck flexor endurance between adolescents with and without migraine, which is in direct contrast to our findings. The age difference between the participants in both studies suggests that migraine may be associated with reduced neck muscle endurance only in individuals who have had the condition over a longer time. Given that there have been no previous reports describing the mean holding time for the extensors in patients with migraine, comparison data are restricted to the flexors.

When comparing our findings with previously published normative data for women, based on studies that used the same test position used in the current study, the median hold time (60.5 seconds) for our control group is similar to the normative cutoff value of 60 seconds reported by Ylinen et al,[41] but higher than the 37 seconds reported by Peolsson et al.[34] In fact, the median hold time (35.0 seconds) for those with migraine in our study compares favorably with the normative values published by Peolsson et al.[34]

The only previously published study, to our knowledge, that has reported normative data for the neck extensor test in healthy women did not use excessive head displacement as a criterion to interrupt the test,[34] which may explain why the mean holding time (507 seconds) reported by that study is much higher than the median scores reported in our study (healthy controls, 290.5 seconds; migraine, 166.5 seconds).

Based on the findings of this study, it should be considered that the presence of migraine is associated with a lower endurance of the cervical spine musculature; however, the higher prevalence of neck pain reported by those with migraine could have also influenced muscle endurance. In fact, the lower median endurance scores of individuals with a history of neck pain in both groups suggest that lower performance in the group with migraine could be attributed, in part, to the much larger proportion of individuals with a history of neck pain in that group. However, patients with migraine demonstrated lower holding times than the control group, even when considering the subgroups of those with and without a history of neck pain. Similarly, the relationship between lower neck flexor and/or extensor muscular endurance and neck pain is unclear, as some studies have reported a difference between patients and controls[17,23,27,35,37] and others have not.[6,15,28,33,37]

Another interesting result of the present study is the difference in the median holding times for those with or without neck pain reported during the test. When we considered the frequency of neck pain during the test, we observed similar rates between those with or without migraine. However, participants with migraine and neck pain had a shorter median holding time in contrast to a longer median holding time in controls. Therefore, it seems that, for controls, the report of neck pain during the test might be related to a longer period of sustained muscle contrac-

TABLE 2 HOLD TIME FOR NECK FLEXOR AND EXTENSOR MUSCLE ENDURANCE TESTS*

	Neck Flexor Test		Neck Extensor Test	
	Migraine Group	Control Group	Migraine Group	Control Group
All participants§	35.0 (30.0)	60.5 (36.3)†	166.5 (135.3)	290.5 (213.3)‡
History of neck pain‖	37.0 (36.3)	56.0 (39.0)	153.0 (101.3)	203.0 (63.5)
No history of neck pain¶	33.0 (13.8)	62.0 (33.5)	228.5 (185.3)	322.0 (214.5)
Neck pain during the test#	24.5 (31.3)	71.0 (52.5)	149.0 (175.8)	365.5 (233.0)
No neck pain during the test**	35.5 (28.0)	53.0 (32.5)	177.5 (104.25)	256.0 (142.3)

*Values are median (interquartile range) seconds.
†P<.001, between-group difference obtained from the Mann-Whitney U test.
‡P = .001, between-group difference obtained from the Mann-Whitney U test.
§Migraine group, n = 26; control group, n = 26.
‖Migraine group, n = 18; control group, n = 3. These data were not analyzed statistically due to the low sample size of the control group.
¶Migraine group, n = 8; control group, n = 23. These data were not analyzed statistically due to the low sample size of the migraine group.
#For the neck flexor test: migraine group, n = 10; control group, n = 7 and for the neck extensor test: migraine group, n = 12; control group, n = 12. These data were not analyzed statistically due to the low sample size of each group.
**For the neck flexor test: migraine group, n = 16; control group, n = 19 and for the neck extensor test: migraine group, n = 14; control group, n = 14. These data were not analyzed statistically due to the low sample size of each group.

tions, whereas for patients with migraine, neck pain may have contributed to lower muscular endurance values. Additionally, the occurrence of pain referred to the head during the endurance test was only observed within the migraine group and potentially also contributed, in part, to lower endurance.

The assessment of cervical muscle performance in patients with migraine is not common practice in physical therapy. In a recent international Delphi study including physical therapists,[29] muscular endurance tests did not rank among the list of useful examination tests for the evaluation of musculoskeletal impairments in that patient population. Additionally, more than 50% of physical therapists believed cervical muscle strength to be either probably or definitely not a useful parameter to assess in individuals with migraine, and approximately 50% had the same opinion for the assessment of individuals with cervicogenic and tension-type headaches.[29] However, findings of the present study, along with other recent reports, suggest that decreased cervical spine muscle performance may be associated with migraine and often coexisting neck pain, particularly for the neck extensors.[11,12,21]

Nevertheless, some potential limitations of this study should be recognized. First, the absolute data should be interpreted with caution, given that there are several variations of cervical muscle endurance tests in the literature. Considering the high variability of the endurance scores, better knowledge of measurement errors (minimum detectable change and minimal clinically important difference) would also be helpful in the interpretation of the data within and between studies.[28] In our study, for the flexor endurance test, the between-group difference was greater than the standard error of measurement reported for healthy controls (8-13 seconds)[19,28,41] and for individuals with neck pain (6-7 seconds).[7,28] Similarly, for the extensor endurance test, the observed difference was greater than the standard error of measurement reported for asymptomatic individuals (50 seconds)[28] and those with neck pain (26-44 seconds).[7,28] Yet, the interpretation of data among studies is still tenuous.

Second, the higher prevalence of individuals with a history of neck pain within the migraine group could be considered a confounding factor. However, this may reflect clinical practice, with population-based research studies reporting an approximately 80% prevalence of neck pain in individuals with migraine.[2] Third, the participants of the pilot study were included in the current sample, which might have influenced the results. Finally, the cross-sectional design does not allow determination of whether cervical muscle dysfunction is a cause or an effect of migraine and often-associated neck pain.

CONCLUSION

Women with migraine had a lower holding time for cervical spine flexor and extensor musculature compared to that of a matched control group. These results suggest that cervical spine muscle endurance may be an important and potentially overlooked aspect of cervical spine muscle function in this population. This impairment may be a modifiable characteristic that may assist in the management of patients with migraine. ◉

KEY POINTS

FINDINGS: Women with migraine have reduced neck muscle endurance.

IMPLICATIONS: Addressing impairments of the neck musculature in women with migraine may assist in the management of this patient population, which also often presents with neck pain.

CAUTION: Despite the pragmatic approach of this study, the results are restricted to women with migraine and may have been influenced by the high rates of associated neck pain. The cross-sectional nature of the study also precludes a conclusion of a direct cause-and-effect relationship between migraine, a history of neck pain, and limited neck musculature endurance.

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