Relationship Between Headaches and Neck Pain Characteristics With Neck Muscle Strength

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Abstract

Objective: The purpose of this study was to assess the correlations between neck muscle strength and pain features, such as neck-related disability, neck pain frequency and intensity, and headache frequency in women with headache. **Methods:** Seventy women with migraine between 18 and 55 years of age diagnosed according to International Headache Society criteria were assessed. Participants provided clinical information regarding neck pain and headache. The Neck Disability Index was used to assess neck-related disability, and neck muscle strength was assessed via maximum voluntary contraction during flexion, extension, and lateral flexion with a handheld dynamometer. The correlation was verified with Spearman's correlation coefficient (ρ). Multiple linear regression was performed to verify whether the clinical variables could predict the strength of neck muscles. All calculations were performed adopting a level of significance of 0.05. **Results:** Neck extensor strength was negatively correlated with all clinical variables (ρ_{range} = –.24 to –.32, $p < .05$); lateral flexor strength was negatively correlated with headache frequency, neck pain intensity, and neck-related disability (ρ_{range} = –.27 to –.39, $p < .05$); and flexor strength also correlated negatively with neck pain intensity and related disability (ρ_r = –.26 to –.29, $p < .05$). Headache frequency and neck pain intensity were identified as significant predictors of the strength variability in extension ($R^2 = 0.16$, $p < .05$) and in lateral flexion ($R^2 = 0.18$, $p < .05$). **Conclusions:** For the women with migraine in this study, correlations of headache and neck pain with neck muscle strength features were weakly to moderately negative. Headache frequency and neck pain intensity may influence a small proportion of the strength variability in extension and lateral flexion. (J Manipulative Physiol Ther 2018;41:650-657)
Key Indexing Terms: *Migraine Disorders; Neck Pain; Muscle Strength Dynamometer; Regression Analysis*

Introduction

Cervical spine dysfunctions are characterized by the presence of neck pain and referred head and upper limb pain.[1,2] Neck pain is highly prevalent and disabling among the population in general[3] and occurs even more frequently among individuals who experience migraines and tension-type headaches, especially in women between the ages of 35 and 49.[4-7] Neck pain has also been reported as being more prevalent than nausea among those who experience migraines,[8] and it can precede headache attacks.[9]

The relationship between neck pain and headaches can be explained by the sensitization of the trigeminocervical nucleus, which receives convergent afferences from the first 3 cervical roots (C1–C3), meningeal blood vessels, and trigeminal nerve, with cranial and mandibular branches.[2,10-13] Once this nucleus is sensitized, it creates a potential source of pain being misperceived, indicating that neck pain can be a symptom from cervical spine dysfunction but also a result of other conditions, such as headaches and temporomandibular disorders.[2]

It has been reported that subjects with neck pain present with weakness and greater fatigability.[1,14-18] Among the several factors that could affect the neck muscles performance, pain has been considered an important one.[14] In addition, improvement in neck muscle strength has been linked to a reduction of neck pain intensity and neck-related disability index.[19,20]

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Therefore, it would be plausible that neck muscle performance would be commensurate with the severity of neck pain; however, reports on the correlation between these variables have been conflicting.[1,14,17,21-23] Studies that assessed subjects with neck pain reported no significant correlations between neck muscle strength/fatigue and neck pain intensity or neck-related disability.[21-24] Only the antagonist activity during neck flexion was found to correlate positively with neck pain intensity and neck-related disability of women with neck pain,[17] indicating that the higher the intensity and related disability reported, the greater the antagonist activity expected. Conversely, studies that assessed subjects with neck pain in association with temporomandibular disorders indicate that both neck muscle strength and fatigue are significantly (but weakly) negatively correlated with neck-related disability and neck pain intensity.[1,14,25]

Recent studies have indicated that women with migraines present with more intense neck pain and greater prevalence of neck-related disability as assessed with the Neck Disability Index.[4,26,27] In addition, severity of neck-related disability is associated with migraine chronification, with an increased prevalence ratio of 4 times.[26,27] Also, a reduction in the strength of cervical extensors has been reported in women with chronic migraine.[28]

The reported association that neck pain, neck-related disability, and neck muscle weakness have with migraine[4,5,7,8,26,27,29] does not guarantee a direct or inverse relationship among them, nor does it guarantee that migraine features and neck pain characteristics have a direct influence on neck muscle strength. Therefore, the aim of the present study was to assess the correlation between neck muscle strength in all directions of movement and the clinical variables related to headaches, such as headache onset and frequency, and neck pain features, such as frequency, pain intensity, and neck disability index. Also, we aimed to assess if the clinical characteristics related to neck pain and headache could indicate altered neck muscle strength.

Methods

Ethical Aspects

The study was approved by the ethics committee of Ribeirão Preto Clinic's Hospital and Ribeirão Preto Medical School, University of São Paulo (Process No. 16692/2012) in accordance with the Helsinki Declaration of 1975. The persons who agreed to participate signed an informed consent form, which contained information about the investigation, the freedom to adhere to or quit the study at any time, absence of harm, and right to anonymity.

Sample

The study screened participants among the patients of a tertiary hospital between February 2014 and February 2015. Sample size calculation for the correlation was performed using the G*Power 3.1.9.2. A minimum of 58 subjects were required based on detecting significant moderate effect size (ρ = .4) with a α of .05 and a desired power of .90. The multiple linear regression required a minimum of 50 participants, considering the suggestion of a minimum of 10 cases per variable to have a relatively stable model[30] and the 5 preliminarily suggested independent variables: headache onset, headache frequency, Neck Disability Index (NDI), neck pain frequency, and intensity.

Inclusion criteria were female sex, age between 18 and 55 years, and migraine diagnosis by experienced neurologists according to the criteria suggested by the International Headache Society.[31] The exclusion criteria were presence of other concomitant headaches; history of face or neck injury; fibromyalgia; history of herniated disk or cervical vertebral arthrosis according to medical records; receipt of an anesthetic block in the prior month of the study; and pregnancy.

Participants who met the criteria were invited by an assessor responsible for the trial to attend to the physical examination at the laboratory set. It was scheduled according to their availability. All participants were under tailored pharmacologic treatment. They were instructed to refrain from taking any analgesic in the 24 hours before the appointment and, in the case of a migraine attack, to call us to reschedule it.

At the physical assessment day, the same assessor used a structured form to collect demographic and clinical data including headache frequency (d/mo), headache onset (years), and neck pain features, including frequency (d/mo) and intensity (numeric pain scale, 0–10).

Neck Disability Index

Neck-related disability was assessed using the NDI, a 10-item scaled questionnaire that measures the influence of neck pain on activities of daily living. The items are related to "pain intensity," "personal care," "lifting," "sleep," "driving," "headaches," "concentration," "reading," "work," and "recreation."[32] NDI is a unidimensional tool (neck pain-related disability), has good internal consistency (Cronbach's α = .87), and can discriminate the levels of disability very well in patients with chronic neck pain.[33] The score can range from 0 to 50 and classifies individuals as having no disability (0–4), mild disability (5–14), moderate disability (15–24), severe disability (25–34) and complete disability ($\geq$35).[34] The Brazilian version of the NDI used in this study has been cross-culturally translated and validated; it is also classified as unidimensional and has good internal consistency (Cronbach's α = .74).[34]

Maximum Strength

After the clinical data registration, an examiner blinded to the migraine and neck pain characteristics measured the maximum isometric voluntary contraction using a handheld dynamometer (Lafayette Instrument Co, Lafayette, Indiana). Participants were assessed in a pain-free period and

Table 1. *Description of Clinical Characteristics of Headaches and Neck Pain and Distribution of Patients by NDI Category*

Clinical Characteristics	Headache (n = 70)					
	N (%)	Mean	Median	SD	Minimum	Maximum
Age (y)		32.29	30.0	10.98	18.0	55.0
Headache frequency (d/m)		11.56	8.50	8.09	1	30
Headache onset (y)		15.23	12.00	10.35	1.00	50.00
Presence of neck pain	57 (83)					
Neck pain frequency (d/mo)		13.82	8.0	10.29	0	30
Neck pain intensity (0–10)		6.12	7.0	2.27	0	10.0
NDI score		10.67	10.00	6.03	0	25
None	13 (19)					
Mild	36 (51)					
Moderate	17 (24)					
Severe	4 (6)					
Complete	0 (0)					

NDI, Neck Disability Index; *SD*, standard deviation.

strength measurement was interrupted if the participant reported a migraine attack. The following movements were randomly assessed: flexion, extension, and bilateral lateral flexion.

The positions for each movement were as follows: (1) strength of neck flexors was measured in dorsal decubitus, with the knees flexed, the head and neck neutrally positioned, and the arms along the body; (2) strength of neck extensors was measured in ventral decubitus, with the arms along the body; and (3) strength of lateral flexion was measured in lateral decubitus, also with the arms along the body. For all test positions, two Velcro bands were used, one on the shoulder region, at T3, and another on the pelvis, at the iliac crest.[27] The bands stabilized the torso and lower limbs to avoid compensation from other segments during strength production.

Before testing, task familiarization trials were conducted. Each movement was repeated 3 times and sustained for 3 seconds, with a 15-second interval between repetitions and a 2-minute break between movements to avoid fatigue. During the entire movement, volunteers received verbal encouragement to produce maximum strength. The value considered for maximum strength analysis was the peak strength recorded, in kgf, among the 3 repetitions. Means of right and left lateral flexion were calculated and considered as lateral flexion values. To adjust the results to units employed in the international literature, peak values in kgf were converted into Newtons and normalized by the participants' body mass using the following formula: normalized force (N/kg) = maximum muscle strength (kgf) × 9.81/body weight (kg).

Statistical Analysis

The mean, median, standard deviation, and range of values were calculated to describe the sample and strength production of groups. Normality was assessed using the Shapiro–Wilk test. For the correlation analysis, first scatter plots were made to verify if a linear relationship existed between each strength direction assessed with all the clinical variables. Then, Spearman's correlation coefficient (ρ) was calculated between maximum strength test and NDI, neck pain intensity, neck pain frequency, and frequency of migraine attacks. Migraine onset was not linearly related to all directions of strength measures. Correlation coefficient values can range from –1 to 1, and those <0.3 were classified as weak correlations; those from 0.3 to 0.7 as moderate correlations, and those >0.7 as strong correlations.[35]

Multiple linear regression was performed to verify how the clinical characteristics of the migraine patients can predict neck muscle strength. Because it was an exploratory analysis, we used the backward method, adopting force production as the dependent variable and neck pain intensity, neck pain frequency, headache frequency, and NDI as independent variables. Herein, we report only the models that were not found to violate the assumptions of a multiple linear regression, that is, linear relationship between variables, no multicollinearity between predictive variables, homoscedasticity, and

Table 2. *Description of Neck Muscle Strength and Normalized Strength in Each Direction of Movement During Maximum Voluntary Isometric Contraction (n = 70)*

Direction of Movement	Strength (N)	Strength Normalized (N/kg)
Flexion		
Mean	35.71	5.66
Median	33.31	5.14
Standard deviation	14.08	2.35
Minimum	16.68	2.33
Maximum	83.38	13.24
Extension		
Mean	86.31	13.65
Median	85.97	13.77
Standard deviation	31.31	5.17
Minimum	20.60	2.56
Maximum	148.13	24.79
Lateral flexion		
Mean	57.43	9.13
Median	55.98	8.88
Standard deviation	20.51	3.73
Minimum	19.13	2.63
Maximum	98.69	17.62

normal distribution of residuals. Analyses were performed using the SPSS 20.0 (IBM Corp, Armonk, New York), adopting a level of significance of .05.

Results

Seventy women with migraine were selected among 156 eligible patients who agreed to participate. The main reasons for the exclusions were concomitant headaches (*n* = 43), receipt of an anesthetic block in the past month (*n* = 22), history of previous head or neck trauma or diagnostic neck-related disease (*n* = 13), failure to attend the scheduled assessment (*n* = 6), and occurrence of a migraine attack during the assessment (*n* = 2). All 70 women included in the current study were under tailored pharmacological treatment, most commonly composed of prophylactic drugs, such as amitriptyline, propranolol, and topiramate, associated with rescue medications for a migraine attack.

Mean patient age was 32 years (standard deviation [SD] = 11), mean headache frequency 11 d/mo (SD = 8), and mean number of years with headache 15 years (SD = 10). Of these headache patients, 83% presented with neck pain with a mean frequency of 13 d/mo and mean intensity of 6, as per a numeric pain scale. The relationship between presence of headache and NDI score revealed a greater percentage of women with mild to moderate disability (Table 1). In terms of neck muscle strength, lower mean normalized strength values were observed for neck flexors (5.66 N/kg; Table 2).

The analysis revealed that headache frequency has a significant moderate negative correlation with extension strength (–0.31; 95% confidence interval [CI]: -0.51 to -0.07; *P* = .01) and a weak negative correlation with lateral flexion strength (–0.27; 95% CI: –0.48 to –0.04; *P* = .02). A weak negative correlation was detected between neck pain frequency and extension strength (–0.25; 95% CI: –0.46 to –0.01; *P* = .04). Also, neck pain intensity was moderately negatively correlated with lateral flexion (–0.33, 95% CI: –0.53 to –0.10) and weakly negatively correlated with flexion (–0.26; 95% CI: –0.47 to –0.02; *P* = .03). No significant correlation was found between flexion strength and the frequencies of neck pain and headache; between extension and neck pain intensity; or between lateral flexion and neck pain frequency (Table 3).

Significant negative correlations were found between neck muscle strength and NDI for all movements. Moderate correlations were found with extension strength (–0.32; 95% CI: –0.51 to –0.18; *P* = .01) and lateral flexion strength (–0.39; 95% CI: –0.57 to –0.16; *P* = .001), whereas a weak correlation was found with flexion strength (–0.29; 95% CI: –0.50 to –0.06; *P* = .01; Table 3).

Characteristics of the models and coefficients that resulted from the multiple linear regression are detailed in Table 4. The model suggested that the force production in flexion violated one of the assumptions of a multiple linear regression by presenting a nonnormal distribution of its residuals. Accordingly, it is not reported in this article.

Final models suggest that headache frequency and neck pain intensity explain 16% of the variance of the normalized extension force (R^2 = 0.16) and 18% of the variance in the normalized lateral flexion (R^2 = 0.18; see model 3 in Table 4). Greater reduction of the lateral flexion force is predicted by the increase in neck pain intensity (β = –.33) compared with the prediction of headache frequency (β = –.23). On the other hand, for force production during extension, both variables had a similar effect (headache frequency, β = –.26; neck pain intensity, β = –.27).

Discussion

To the best of our knowledge, this is the first report on the relationship between neck muscle strength and clinical features of headache and neck pain in patients with

Table 3. *Correlation [a] of Normalized Neck Strength (N/kg) to Migraine and Neck Pain Variables (n = 70) Determined by Spearman's Correlation Coefficient (ρ)*

Direction of Movement	Headache Frequency (d/mo)	Neck Pain Frequency (d/mo)	Neck Pain Intensity	NDI Score
Flexion				
ρ	–.17	–.12	–.26 [b]	–.29 [b]
95% CI	–.39 to –.07	–.36 to .12	–.47 to –.02	–.50 to –.06
P value	.16	.30	.03	.01
Extension				
ρ	–.31 [b]	–.25 [b]	–.24 [b]	–.32 [b]
95% CI	–.51 to –.07	–.46 to –0.01	–.46 to 0.003	–.51 to –.08
P value	.01	.04	.46	.01
Lateral flexion [c]				
ρ	–.27 [b]	–.22	–0.33 [b]	–.39 [b]
95% CI	–.48 to –.04	–.44 to .02	–.53 to –.10	–.57 to –.16
P value	.02	.07	.005	.001

CI, confidence interval; *NDI,* Neck Disability Index.
[a] Correlation classified as weak (ρ < .30), moderate (.3 < ρ > .7) or strong (ρ > .7).
[b] Evidence of a linear correlation, with a level of significance of .05.
[c] Mean of right and left lateral flexion strength measures.

migraine and the first to reveal the predictive value of some of these features. Our data revealed that neck muscle strength of women with headache has a negative weak to moderate correlation with headache and neck pain variables in most directions of movement. In addition, frequency of headache and intensity of neck pain were the only clinical variables observed to have predictive value related to neck muscle strength measurements. Together, they were able to justify 16% of neck extensor force variability and 18% of lateral flexor variability in our sample.

The significant negative correlation between force measurements and some of the clinical variables suggest that in women with migraine, the lower the neck muscle strength, the greater the neck-related disability, neck pain intensity, and headache frequency. With respect to neck disability, our results are in accordance with the weak correlation between neck flexor strength and disability reported for female patients with temporomandibular disorders.[1] However, it differs from those previously reported for women with chronic nonspecific neck pain[22] or patients with nonspecified cervical disorders,[24] which have demonstrated no significant correlation between neck disability and neck strength.

We cannot exclude that characteristics of the sample or method applied to assess strength may contribute to the similarities and discrepancies between these results. Armijo-Olivo et al[1] assessed women with a mean age of 32 years and measured flexor strength with the participants in a supine position, very similar to our study. On the other hand, those who reported no significant correlation differed from ours by including both sexes,[24] having a sample with greater mean age,[22,24] or measuring strength with participants in a seated position.[22]

It is also possible that the relationship between pain and force production can vary depending on the source of pain. We suggest this may be due to occurrence of a similar significant, but weak, correlation in a sample with recognized combined chronic pain conditions, that is, neck pain plus temporomandibular disorders,[1] despite the absence of correlation in those who reported only neck pain.[22,24]

The current findings add to the understanding of neck disability in patients with migraine because of the negative correlation not only with neck muscle strength but also with neck pressure–pain threshold[36] and cervical range of motion.[26] These findings also indicate that headache frequency and neck pain intensity are moderately negatively correlated with neck muscle strength, especially in extension and lateral flexion. The low magnitude of the coefficients found here might raise questions about the coefficients' clinical significance.[1] However, it should be considered that pain is multidimensional,[37] and robust correlations with a strict biological measure would not be expected.

Table 4. *Multiple Linear Regression Using the Backward Method With the Neck Muscle Strengths Measured With a Handheld Dynamometer as the Dependent Variable and the Headache and Neck Pain Clinical Characteristics as the Independent Variables*

Dependent Variable	Model Parameters	Independent Variable	*B*	SE *B*	β
Normalized extension (N/kg)	Model 1 R^2 = 0.17 R^2 adjusted = 0.12 F = 3.31, P = .02	Constant	18.13	1.40	
		NDI	–0.14	0.13	–.16
		Headache frequency	–0.12	0.09	–.19
		Neck pain frequency	–0.01	0.07	–.02
		Neck pain intensity	–0.31	0.26	–.18
	Model 2 R^2 = 0.17 R^2 adjusted = 0.13 ΔR^2 = 0 F = 4.47, P = .01	Constant	18.16	1.37	
		NDI	–0.14	0.13	–.16
		Headache frequency	–0.12	0.08	–.19
		Neck pain intensity	–0.32	0.23	–.19
	Model 3 R^2 = 0.16 R^2 adjusted = 0.13 ΔR^2 = –0.01 F = 6.14, P = .004	Constant	17.88	1.35	
		Headache frequency	–0.16	0.07	–.26 [a]
		Neck pain intensity	–0.46	0.19	–.27 [a]
Normalized lateral flexion (N/kg)	Model 1 R^2 = 0.20 R^2 adjusted = 0.15 F = 4.00, P = .01	Constant	12.73	1.00	
		NDI	–0.10	0.09	–.17
		Headache frequency	–0.09	0.06	–.19
		Neck pain frequency	0.03	0.05	.08
		Neck pain intensity	–0.35	0.18	–.29
	Model 2 R^2 = 0.20 R^2 adjusted = 0.16 ΔR^2= –0.004 F = 5.29, P = .003	Constant	12.64	0.98	
		NDI	–0.10	0.09	–.16
		Headache frequency	–0.08	0.06	–.17
		Neck pain intensity	–0.31	0.17	–.26
	Model 3 R^2 = 0.18 R^2 adjusted = 0.16 ΔR^2= –0.01 F = 7.39; P = .001	Constant	12.45	0.96	
		Headache frequency	–0.10	0.05	–.23 [a]
		Neck pain intensity	–0.41	0.14	–.33 [a]

NDI, Neck Disability Index; *SE,* standard error.
[a] $P < .05$, Student's *t* test for β.

The absence of a linear relationship between neck muscle strength and the chronicity of migraine disease (ie, headache onset) was surprising because several muscle impairments are expected to be related to the chronicity of pain and disability.[38] However, it reinforces that the relationship between pain characteristics and neck muscle strength reported here is not a direct consequence of the years living with pain but may be specifically related to headache disorders associated with neck pain. Indeed, multiple linear regression analysis identified that both headache frequency and neck pain intensity have the potential to predict between 16% and 18% of the variability of the extensors and lateral flexor strength measured with a handheld dynamometer.

The best multivariate result leaves 82% of the extension and lateral flexion strength variability without explanation. Lindstroem et al[18] reported a similar proportion of predictive value to explain strength measures in patients with chronic neck pain using a model that combined the NDI scores and the Fear-Avoidance Beliefs Questionnaire (R^2 = 0.187). Theoretically, many other factors, for example, psychological, physical, and social factors, which were not explored in either study, could interfere in the variability of neck strength. The best scenario for future studies would be a model that combines physical and psychosocial factors to identify what combination of variables could better explain the variability in neck muscle strength.

Limitations

One limitation of the present study is the inability to generalize results to other groups of migraine and headache patients because participants were recruited from a tertiary clinic, resulting in high-complexity pain cases. Also, we cannot assume that the same relationship would be observed in men with migraine or women in a different age range. The inclusion criteria adopted were chosen to represent the majority of the migraine population based on its epidemiological profile, that is the range of age and sex that have the highest prevalence.[39,40] However, sex differences in the migraine clinical profile, force production, and coping behaviors[40-42] may result in a different relationship, so future investigations into this correlation in males is encouraged.

Finally, causality cannot be assumed because of the study design. For the moment, we can only suggest a bidirectional relationship. Weakness of neck muscles could occur as a consequence of the worse headache and neck pain clinical presentation. Also, the presence of altered neck muscle performance in migraineurs could be related to the aggravation or perpetuation of neck pain intensity, headache frequency, and neck-related disability.

Conclusion

In this study, women with migraines had moderate to weak correlations among neck muscle strength and neck-related disability, neck pain frequency, neck pain intensity, and headache frequency. Moreover, headache frequency and neck pain intensity may possibly influence strength in extension and lateral flexion. Posterolateral muscle strength may be considered during the assessment and treatment of patients with migraine.

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Contributorship Information

Concept development (provided idea for the research): D.B.-G., F.D., L.L.F.
Design (planned the methods to generate the results): L.L.F.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): D.B.-G., G.F.C., F.D.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): G. d.A.T., A.P.d.O.C.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): G.d.A. T., L.L.F.
Literature search (performed the literature search): G.d. A.T., A.P.d.O.C.
Writing (responsible for writing a substantive part of the manuscript): G.d.A.T., L.L.F.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking; D.B.-G., G.F.C., A.P.d.O.C., F.D.

Practical Applications

- Neck strength may contribute to headache and neck pain features in women.
- Greater headache and neck pain frequencies, worse severity of neck pain, and greater neck-related disability were correlated with lower neck muscle strength in all directions of movement.
- Headache frequency and neck pain intensity may influence the neck muscle strength in women with migraine.

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