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Pain sensitization and atrophy of deep cervical muscles in patients with chronic tension-type headache

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SUMMARY

OBJECTIVE: The aim of this study was to compare the pressure pain threshold and the thickness of the cervical muscles in patients with tension-type headache versus healthy participants.

METHODS: An observational, retrospective, cross-sectional study was conducted at the Universidad Europea de Madrid between May and June 2022. Adults aged 18–65 years with tension-type headache diagnosed for more than 6 months were compared to healthy controls. B-mode ultrasound imaging was employed to measure the thickness of the neck stabilizing muscles, longus colli, and multifidus at the C5 and C6 levels, respectively. pressure pain threshold measurements were assessed bilaterally in the following regions: upper trapezius, masseter, temporalis, anterior tibialis, and median nerve.

RESULTS: A total of 40 participants (90% females; 36.3±12.9 years, BMI 24.2±3.7 kg/m^2) participated in the study. Compared with the control group (n=20), participants in the tension-type headache group (n=20) presented statistically significant lower values in all pressure pain threshold measures. Additionally, the tension-type headache group presented statistically significant lower values in the thickness of the following muscles: right multifidus at rest (1.0±0.2 cm versus 1.3±0.2 cm; p<0.001), left multifidus at rest (1.1±0.1 cm versus 1.3±0.1 cm; p<0.001) and during contraction (1.2±0.1 cm versus 1.5±0.2 cm; p<0.001), left longus colli at rest (1.0±0.2 cm versus 1.2±0.1 cm; p=0.01) and during contraction (1.2±0.2 cm versus 1.4±0.1 cm; p<0.001), and right longus colli during contraction (1.2±0.2 cm versus 1.4±0.2 cm; p=0.02).

CONCLUSION: This study concluded that patients with tension-type headache showed lower thickness and lower pressure pain threshold of cervical muscles compared to healthy controls.

KEYWORDS: Neck pain. Neck muscles. Tension type headache. Muscle atrophy.

INTRODUCTION

Tension-type headache (TTH) is the most prevalent type of headache, affecting 36–78% of adults[1]. It shares similarities with migraines, occurring in both episodic and chronic forms[2]. Both TTH and migraines are more common in females, with a ratio of 3:1 compared to males[3].

The association between cervical pathology and headaches appears to be linked to the convergence of nociceptive input from the upper cervical spine and trigeminal input at the trigeminal-cervical nucleus level[4]. This convergence justifies the ability to reproduce headaches by applying pressure to cervical structures[5] and the sensitization of areas innervated by the trigeminal-cervical nucleus. This sensitization can be measured using algometry, which has shown reduced values in the craniocervical region. Patients with TTH have greater pressure sensitivity in craniocervical muscles such as the upper trapezius, suboccipital, temporalis, and masseter muscles, compared to healthy subjects[6].

In addition, some studies have observed reduced pressure sensitivity in remote areas from the cervical region, such as the tibialis anterior muscle, in patients with TTH[7], suggesting a process of central sensitization that is more pronounced in females.

Muscle pain, loss of strength, and lower motor control seem to be correlated in patients with TTH[8]. Consequently, it is conceivable that the loss of strength may be associated with changes in the thickness of cervical muscles, but the results are not clear[9]. The conflicting results and the generally low methodological quality of the existing studies on this topic prevent definitive conclusions from being drawn.

Therefore, the aim of this study was to analyze the pressure pain threshold (PPT) and the thickness of cervical muscles at rest and during contraction in patients with TTH.

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METHODS

Study design and ethical considerations

An observational, cross-sectional study was conducted at the Universidad Europea de Madrid following the STROBE guidelines between May and June 2022. This study followed the Declaration of Helsinki guidelines. The study was approved by the Research Ethics Committee of the Rey Juan Carlos University of Madrid (ID: 1802202105721). All the participants read and signed an informed consent statement before participating in this investigation.

Participants

The participants for this study were recruited from students and workers at the Universidad Europea de Madrid (Spain), who were included in the study if they fulfilled the following criteria: (1) adults aged 18–65 years and (2) diagnosis of TTH for more than 6 months, confirmed by their neurologist, using the criteria of the International Headache Society classification of headaches (ICHD-3). The most significant finding was increased tenderness in pericraneal muscles such as masseter, temporal, and upper trapezius.

Inclusion criterion for controls was the absence of headache. Exclusion criteria were as follows: (1) the presence of pathologies that prevent the performance of physical activity; (2) pregnancy; (3) concomitant severe respiratory, cardiovascular, or neurological disease; and (4) previous whiplash injury or neck fracture. Participants with TTH were matched with their controls by age, sex, and body mass index (BMI).

Sample size

The sample size calculation was realized using the G*Power 3.1.9 software (G*Power ©, University of Dusseldorf, Düsseldorf, Germany). A two-tailed hypothesis with an effect size of 0.81, an alpha error of 0.05, a statistical power of 0.8, and an allocation ratio of 1 were performed. Therefore, the total sample size was 40 participants, who were divided into two groups (n=20): the TTH group and the control group.

Measurements

First, the following anthropometric variables were collected: age in years, height in centimeters (cm), weight in kilograms (kg), and BMI (kg/m^2).

Then, the characteristics of headache episodes were assessed. The duration of headaches was measured in hours, the intensity on the numerical pain rating scale ranged from 0 (no pain) to 10 (maximum pain), and the frequency of the episodes was measured in days[10].

Next, to measure the PPT, a FORCE DIAL FDK/FDN 100 algometer (Wagner Instruments, Greenwich, USA) was used as the measurement tool. PPT is known to be the most validated mechanical threshold at present[11]. Patients were taught to be familiarized with the procedure by testing it in a non-involved area in the study (vastus medialis). The procedure was repeated three times with a resting period of 30 s between repetitions. Patients were instructed to report when pain appeared while exerting pressure with the algometry device, that is, the first pain signal. Pressure was applied progressively at a smooth pace of 1 kg/s. The average was calculated from all repetitions. Participants were assessed while laying supine on a stretcher by a physiotherapist. PPT measurements were performed bilaterally in the following regions: trapezius, masseter, temporalis, anterior tibialis, and median nerve in the flexion crease of the elbow, in order to determine if low values over these spots in headache participants could determine a relation between headache and central and peripheral mechanical pain sensitivity[12]. Intraclass correlation coefficients were considerably high (ICC: 0.83–0.89). In addition, intraexaminer (ICC=0.94–0.97) and interexaminer reliability (ICC=0.79–0.90) were elevated[13].

Finally, the thickness of the neck stabilizing muscles, multifidus, and flexor longus colli was measured at the cervical C5 and C6 levels, respectively. It was assessed by using ultrasonography (GES7, GE Healthcare, Chicago, USA) both at rest and during counter-resistance, following the methodology of Øverås and collaborators[14]. Participants laid in a supine position for flexor longus colli and prone for multifidus assessments. Counter-resistance contraction was performed by instructing the participant to reproduce a double-chin command in case of flexor longus colli, and isometric neck extension to evaluate multifidus. Contraction was maintained for 3 s. The procedure was repeated three times with a resting period of 30 s between repetitions, and the average measurement was calculated and recorded. Inter-rater reliability of thickness during contraction was found to be good for longus colli muscles and moderate-to-low for multifidus.

Statistical analysis

Shapiro-Wilk test was performed to observe whether the distribution was parametric or non-parametric for all variables. Then, independent samples t-test was performed to determine whether there were significant differences between the TTH group and the control group in all parametric variables. The Mann-Whitney U test was performed for the non-parametric variables. For the categorical variable (sex), an exact Fisher's test was performed. The significance level was set at

alpha <0.05. All analyses were performed using the SPSS 27.0 (IBM) statistical software.

RESULTS

Sociodemographic data

A total of 40 participants (36 females, 90%) with a mean age of 36.3±12.9 years, a height of 165.11±10.65 cm, a weight of 66.1±11.1 kg, and a BMI of 24.2±3.7 kg/m^2 participated in the study, with no significant differences in these variables between the TTH group (n=20) and the control group (n=20) (Table 1).

Pain characteristics

The TTH group had headache episodes with a mean frequency of 11.1±9.5 days per month, a pain intensity of 6.9±1.7 (on a scale of 0 to 10), and a duration of episodes of 10.4±8.9 h.

Pain pressure threshold

The TTH group presented statistically significant lower values in all PPT measures compared with the control group, i.e., in left temporalis (p<0.001), right temporalis (p<0.001), left upper trapezius (p<0.001), right upper trapezius (p<0.001), left masseter (p<0.001), right masseter (p<0.001), left median nerve (p<0.001), right median nerve (p<0.001), left anterior tibialis (p<0.001), and right anterior tibialis (p<0.001) (Table 2).

Ultrasound thickness

The THG presented statistically significant lower values in the thickness of the following muscles: right multifidus at rest (p<0.001), left multifidus at rest and during contraction (p<0.001), left flexor longus colli at rest (p=0.01) and during contraction (p<0.001), and right flexor longus colli during contraction (p=0.02). No significant differences were detected in the thickness of the right multifidus during contraction or in the right flexor longus colli at rest (Table 3).

Table 1. Sociodemographic data of the tension-type headache group and control group.

Variables	TTH group (n=20)	Control group (n=20)	p-value
Sex (male/female)	2/18	2/18	n.s
Age (years)	37.5±13.1	35.9±12.2	n.s
Height (cm)	166.12±11.09	164.98±10.02	n.s
Weight (kg)	67.88±12.08	65.8±10.90	n.s
BMI (kg/m^2)	24.38±3.80	24.11±3.98	n.s

Data are presented as mean±standard deviation or n (sex). n.s: non-significant.

DISCUSSION

This study compared the PPT and the thickness of the cervical muscles in patients with TTH compared to healthy participants. The PPT in the upper fibers of the trapezius, masseter muscle, temporal muscle, tibialis anterior muscle, and median nerve were lower in participants with TTH compared with controls. In addition, the thickness of the cervical muscles (multifidus and longus colli) of the TTH group at rest and during contraction was lower compared with the control group.

Table 2. Pain pressure threshold of the participants.

Variables	TTH group (n= 20)	Control group (n=20)	p-value
PPT temporalis R (kg/cm^2)	3.0±1.0	5.6±0.5	<0.001*
PPT temporalis L (kg/cm^2)	2.9±1.1	5.6±0.4	<0.001*
PPT upper trapezius R (kg/cm^2)	3.5±1.6	6.5±0.7	<0.001*
PPT upper trapezius L (kg/cm^2)	3.5±1.6	6.6±0.7	<0.001*
PPT masseter R (kg/cm^2)	2.4±1.0	4.5±0.5	<0.001*
PPT masseter L (kg/cm^2)	2.3±0.9	4.4±0.5	<0.001*
PPT median nerve R (kg/cm^2)	3.6±1.4	6.0±0.7	<0.001*
PPT median nerve L (kg/cm^2)	3.5±1.2	6.1±0.7	<0.001*
PPT tibialis anterior R (kg/cm^2)	6.3±1.3	10.2±1.0	<0.001*
PPT tibialis anterior L (kg/cm^2)	6.5±1.7	10.1±0.9	<0.001*

L: left; R: right. *Level of significance: p<0.05. Data are presented as mean±standard deviation.

Table 3. Thickness of the cervical multifidus (C5) and longus coli.

Thickness	TTH group (n=20)	Control group (n=20)	p-value
R multifidus (cm)	1.0±0.2	1.3±0.2	<0.001*
R multifidus cont (cm)	1.2±0.2	1.5±0.2	0.07
L multifidus (cm)	1.1±0.1	1.3±0.1	<0.001*
L multifidus cont (cm)	1.2±0.1	1.5±0.2	<0.001*
R longus colli (cm)	1.0±0.2	1.1±0.1	0.2
R longus colli cont (cm)	1.2±0.2	1.4±0.2	0.02*
L longus colli (cm)	1.0±0.2	1.2±0.1	0.01*
L longus colli cont (cm)	1.2±0.2	1.4±0.1	<0.001*

R: right; L: left; cont, contracted. *Level of significance: p<0.05. Data are presented as mean±standard deviation.

Several studies have shown the relationship between anterior/posterior craniocervical muscular atrophy and neck pain or cervicogenic headache[15]. The results observed in this study show that people with TTH present a decrease in muscle thickness/atrophy in the multifidus and longus colli muscles. These findings could be associated with a decrease in cervical muscle strength, as described in the study conducted by Madsen et al.[16], where they found lower levels of strength in the extensor and cervical flexor muscles in participants with TTH compared to healthy controls. Similarly, some studies[17] have shown that a flexor muscle strengthening program managed to reduce pressure pain in patients with TTH.

In addition to the differences in the thickness of the cervical musculature, this study also observed a decrease in PPT in (i) craniocervical region, including upper fibers of the trapezius, masseter muscle, and temporalis muscle; and (ii) extra-craniocervical region, including anterior tibialis muscle and median nerve. PPT determined by algometry is a valid and reliable method for measuring craniocervical muscles[18].

Pain perception studies that evaluated the muscle sensitivity in patients with headache have clarified the pathophysiological mechanisms. It is now accepted that peripheral and central sensitization phenomena play an important role in the onset and maintenance of tension headache[18]. According to this model that tries to explain the pathophysiology of TTH, central sensitization could be the reason why episodic TTH can become chronic because a constant sending of nociceptive stimuli from cervical structures can cause the activation of second-order neurons at the level of the trigeminal caudais nucleus.

The PPT represents the sensitivity of the tissues and can be performed in the craniocervical and/or extra-craniocervical regions. Depending on where these thresholds are decreased, it can be assumed that they reflect signs of sensitization of the trigeminal-cervical nucleus caudalis[19,20]. This neurophysiological model of the trigeminal-cervical nucleus caudalis may explain the appearance and maintenance of tension headaches[21,22].

Therefore, the results of this study support this neurophysiological model since the participants had a TTH lasting more than 6 months. This may explain the differences that have been observed in the PPT of the different points measured, such as extra-craniocervical structures (anterior tibialis and median nerve).

Some limitations associated with this study should be acknowledged. First, the PPT in the suboccipital muscles or levator scapulae was not measured. Only the C5 cervical segment was measured to determine the thickness of cervical multifidus. Finally, it would be interesting for future studies to determine the relationship between the intensity and frequency of episodes with muscular atrophy and the PPT.

In addition, future randomized controlled trials should include a specific neck muscle strengthening program to reduce the associated symptoms in the craniocervical region, along with pain education to reduce the chronicity of these pathologies.

CONCLUSION

This study found that patients with TTH had lower PPT in both craniocervical and extra-craniocervical points, suggesting pain sensitization compared to healthy participants. Moreover, these patients with TTH showed an atrophy of the anterior and posterior deep cervical musculature.

ETHICAL CONSIDERATIONS

This study followed the Declaration of Helsinki guidelines at all times. All the participants read and signed an informed consent statement before participating in this investigation. The study protocol was approved by the Research Ethics Committee of the Rey Juan Carlos University of Madrid on March 31, 2021 (reference number: 1802202105721).

AUTHORS' CONTRIBUTIONS

JABM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Writing – original draft. **AGF:** Data curation, Formal Analysis, Writing – original draft. **DDB:** Conceptualization, Data curation, Writing – original draft. **DMV:** Data curation, Formal Analysis, Methodology. **ASS:** Conceptualization, Data curation, Methodology. **GGPS:** Formal Analysis, Supervision, Validation, Writing – original draft, Writing – review & editing.

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