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Neural Tension Technique Improves Immediate Conditioned Pain Modulation in Patients with Chronic Neck Pain: A Randomized Clinical Trial

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Abstract

Objective. To determine the immediate effect of neural tension technique (NTT) on conditioned pain modulation in patients with chronic neck pain. A secondary objective was to determine the immediate effect of neural tensioner technique on pain intensity and cervical range of movement. **Design**. Randomized clinical trial. **Setting**. University medical center. **Subjects**. Fifty-four patients with neck pain (13 males and 41 females; mean± SD age = 20.91 ± 2.64 years) were randomly allocated to two groups: NTT or sham technique. **Methods**. Participants received a visual analog scale (VAS) and neck disability index (NDI) after inclusion. Conditioned pain modulation (CPM) and active cervical range of motion were measured before and after the intervention. Each subject received one treatment session. **Results**. The results of the analysis of variance revealed a significant effect for the group × time interaction only for CPM ($F = 11.09$, $P = 0.002$, $\eta_p^2 = 0.176$). No significant interactions were found for the other measures (VAS [$F = 1.719$, $P = 0.195$, $\eta_p^2 = 0.031$], pressure pain threshold C2 [$F = 0.731$, $P = 0.398$, $\eta_p^2 = 0.018$], flexion [$F = 0.176$, $P = 0.677$, $\eta_p^2 = 0.003$], extension [$F = 0.035$, $P = 0.852$, $\eta_p^2 = 0.001$], lateral flexions [$F = 0.422$, $P = 0.519$, $\eta_p^2 = 0.008$], and rotations [$F = 1.307$ $P = 0.258$, $\eta_p^2 = 0.024$]). Regarding CPM, intergroup interaction differences were found postintervention ($P = 0.002$) with a high effect size ($d = 0.98$). **Conclusions**. This study suggests that neural tension technique enhances immediate conditioned pain modulation in patients with chronic neck pain, but not pain intensity or cervical range of movement.

Key Words: Chronic Neck Pain; Neural Mobilization; Conditioned Pain Modulation

Introduction

Neck pain (NP) is ranked as the fourth greatest contributor to global disability and the 21st in terms of overall burden [1]. In Spain, NP is the fifth cause of chronic complaints in people older than age 15 years, and the one-year prevalence for NP is estimated to be 19.5%, affecting more women than men (26.4% compared with 12.3%, respectively) [2,3].

In 2015, the Spanish National Health Service (SNHS) allocated a total amount of €52,799,000 for rehabilitation [3]. Treatments offered by the SNHS for chronic NP are exercises, manual mobilization, thermotherapy, and electrotherapy. Approximately half (50.82%) of these treatments are considered ineffective, with inconclusive evidence on effectiveness [4]. Thus, a better understanding of the mechanisms underlying NP and pain modulation is critical when developing a plan of care.

First, NP patients have shown alterations in pain processing that result in localized and widespread hypersensitivity to mechanical stimuli compared with pain-free controls [5,6]. Recent research concludes that symptoms of central sensitization (CS) can be found to a greater extent in patients with chronic nonspecific NP with neuropathic features, where negative biopsychosocial factors are also involved [7]. However, a previous systematic review showed a lack of evidence within nontraumatic NP subjects [8]. In traumatic or whiplash-associated disorders, features of CS, for example, both sensory hypersensitivity (decreased pain thresholds) and hypoesthesia (increased detection thresholds), can be found [9,10].

Second, conditioned pain modulation (CPM) is also thought to be impaired in individuals with chronic pain compared with healthy individuals [11]. Diffuse noxious inhibitory control is an activation of the pain modulation mechanisms that reflects the descending endogenous analgesia system activity. This is mediated by supraspinal areas and networks located in the rostral brainstem, such as the periaqueductal gray matter and the rostral ventromedial medulla [12,13]. In recent years, CPM has been identified as a measure of great research importance for its ability to modulate pain [14]. The most common way to evoke CPM involves the application of a harmful conditioned stimulus and a reliable test to evaluate it, for example, the cold-pressor test [11]. Regarding NP, a recent study showed that a preexisting impairment in CPM is a risk factor to develop new-onset chronic NP [15]. This impairment was also found in patients with chronic whiplash-associated disorders [16,17]. Yet this dysfunction might not be present in chronic idiopathic NP [17], or even in long-term NP [18]. Due to the small sample size used and the lack of evidence in this regard, the current evidence is not sufficient to draw firm conclusions.

The effect of physical therapy modalities, such as TENS [19], and joint mobilization [20] on CPM have shown positive results in patients with chronic pain. NM in animal studies activates the descending inhibitory pain system by means of serotoninergic and noradrenergic pathways in the spinal cord [21]. In healthy human participants, NM has proved to produce an immediate widespread hypoalgesic effect vs placebo [22,23]. The NM techniques, such as tensioning and gliding techniques, aim to restore the mechanical relation of the nerve with its connective tissue [24]. However, the effect of NM on CPM in patients with chronic NP has not been studied yet. We hypothesized that conditioned pain modulation would become more effective following the application of neural tensioner technique than a sham technique.

Thus, the purpose of this study was to determine the immediate effect of neural tensioner technique on conditioned pain modulation in patients with chronic neck pain. A secondary objective was to determine the immediate effect of neural tensioner technique on pain intensity and cervical range of movement. In parallel, we observed the influence of psychological variables on conditioned pain modulation.

Methods

This is a randomized controlled clinical trial and was conducted in accordance with the CONSORT statement [25]. Patients were blinded to group assignment, and the assessor was blinded to allocation. Randomization into two groups (neural tension technique [NTT] and sham technique [ST]) was performed using a computer-generated random-sequence table with a two-balanced block design (GraphPad Software, Inc., La Jolla, CA, USA). A member of the research team who was not involved in the assessment or treatment of the subjects was in charge of the randomization and maintenance of the list. The trial was registered in the US National Institutes of Health Clinical Trials Registry with the registration number NCT02816060.

Participants

Individuals with neck pain were enrolled from the Rey Juan Carlos University Medical Center between June 2016 and November 2016 via recruitment flyers. Individuals were included in the study if they met the following inclusion criteria: aged 18–65 years; neck pain perceived in the posterior region of the cervical spine, from the superior nuchal line to the first thoracic spinous process with more than 12 weeks of evolution and without radicular symptoms radiated to the head, trunk, and/or the upper limbs [9]; and the ability to understand, write, and speak Spanish fluently. They were excluded if they presented: development of systemic or degenerative diseases; symptoms of moderate or severe depression according to Beck's questionnaire [26]; pain in any area of the lower back and/or the head in the last nine months; neck pain associated with whiplash injuries; medical red flag history (i.e., tumor, fracture, metabolic diseases, rheumatoid arthritis, osteoporosis); neck pain with cervical radiculopathy; neck pain associated with externalized cervical disc herniation, fibromyalgia syndrome, previous neck surgery; neck pain accompanied by vertigo caused by vertebrobasilar insufficiency or accompanied by non-cervicogenic headaches due to a traumatic event in the past 12 months; and history of neck or face pain in the last six months. All of the procedures used in this study were planned according to the ethical principles of the Declaration of Helsinki and were approved by the Ethics

Committee of Rey Juan Carlos University. All subjects agreed voluntarily to sign the informed consent for this study.

Procedure

Each subject came to the center for one day. The study protocol was explained to the subject, after which they read and signed an informed consent form. All measurements were performed before and five minutes after the subject received the treatment protocol. First, the participants received a visual analog scale (VAS) and Neck Disability Index (NDI). CPM and active cervical range of motion were also measured before the intervention. Later, subjects received treatment for seven minutes: either NTT or ST. Both interventions were applied at a frequency of 0.5 Hz (with metronome control/steps) for two minutes and repeated three times with 30 seconds of rest time between each mobilization. The VAS, CPM, and active cervical range of motion were also measured after the intervention.

Measures

Conditioned Pain Modulation Assessment

As a primary outcome measure, CPM was tested using the lower extremity submaximal effort tourniquet test, which is a reliable and widely used measure in research [14,27,28]. Initially, a baseline reading of pressure pain threshold (PPT) was assessed using algometry at the dorsal aspect of the midpoint between the base of the nail and the interphalangeal joint of the right thumb. The PPT is defined as the lowest pressure that, using standardized testing conditions, needs to be applied to cause the slightest sensation of pain [29]. PPTs were measured using a digital algometer (FDX 25; Wagner Instruments, Greenwich, CT, USA). After determining the PPT baseline, the conditioning stimulus was induced using a modified submaximal effort tourniquet procedure. Subjects elevated their left leg with ankle dorsiflexion for approximately one minute to obtain partial exsanguination, whereupon the blood pressure cuff was inflated to 250–260 mmHg. After that, subjects then caried out active dorsiflexion exercises with their ischemic leg. After every five repetitions, subjects verbally rated their leg pain until 6 was reached. Although the tourniquet remained inflated, PPT algometry assessment was performed in the same location as previously described (kg/cm^2).

Pressure Pain Threshold . PPT was measured by using the same digital algometer previously described. An average of three measurements was calculated at three points of the cervical spine (a summation was performed from the measurements of the spinous process of C2, right pillar joint of C5-C6, and left pillar joint of C5-C6). It showed a high level of reliability with good interexaminer reliability (ICC = 0.82–0.97) for cervical spine pain [30,31].

Visual Analog Scale

The VAS is a 100-mm line, oriented horizontally, with one end representing "no pain" and the other end representing "worst pain." Subjects were asked to rate their current pain with a mark on the scale [32].

Neck Disability Index . The NDI is a well-validated 10-item questionnaire, with each item rated on a scale from 0 to 5. The sum of the 10 items gives a score between 0 and 50 [33,34]. The NDI has sufficient support in the literature as the most commonly used instrument for reporting neck pain [33,35]; a Spanish validation of the index was used [36]. The total score is expressed as a percentage of the maximum possible [36].

Active Cervical Range of Motion. Active cervical range of motion was assessed with a CROM device (Performance Attainment Associates, Lindstrom, MN, USA). The CROM device consists of three inclinometers (one for each plane of motion) attached to a plastic frame. A standardized protocol was used to reduce potential bias [37]. Patients were seated in a chair, and the CROM device was placed over their head. The assessor asked patients to perform active neck movements in maximum range. CROM measurements were taken before and five minutes after treatment. Trials were completed in the same order: flexion, extension, right rotation, left rotation, right latero-flexion, and left latero-flexion. Three measurements were performed in each direction, and the average value was calculated. CROM has been shown as a reliable measure for patients with neck pain (ICC = 0.88–0.96); the minimum detectable changes are 5.1° for extension, 6.5° for flexion, 4.9° for left rotation, 6.1° for right rotation, 4.2° for left lateral flexion, and 3.6° for right lateral flexion [38].

Confusion Measures

Pain Catastrophizing

The Spanish version [39] of the pain catastrophizing scale (PCS) was used [40]. The PCS is a 12-item questionnaire that measures three components of catastrophizing: magnification, rumination, and helplessness. This version has demonstrated appropriate internal consistency, test–retest reliability, and sensitivity to change [39].

Kinesiophobia

To assess fear of movement and injury, the Tampa Scale for Kinesiophobia (TSK) was used [41]. It has demonstrated good psychometric properties [42]. A Spanish version of the TSK that has 11 items was used in the current study [43].

State Trait Anxiety Inventory

To measure anxiety, the State Trait Anxiety Inventory (STAI) was used. The STAI is a questionnaire consisting of two subscales; each of the two subscales (trait anxiety

Figure 1. Neural tensioner technique. A) Start position. B) Final position.

and state anxiety) consists of 20 items, scored from 0 (none) to 3 (very much) [44]. This questionnaire has shown high convergent validity with other measures of related anxiety [45].

Beck Depression Inventory

The Beck questionnaire is one of the most widely used screening instruments for measuring the severity of depression in patients. The Beck contains 21 items and identifies symptoms and attitudes associated with depression. Each item is evaluated on a severity scale ranging from 0 to 3, with a total score ranging from 0 to 63: 0–10 on the BDI indicates absent or minimal depression, 10–18 mild to moderate depression, 19–29 moderate depression, and 30–63 severe depression. This psychological factor has been used before in patients with neck pain [46–48].

Treatment Protocol

The treatment techniques were applied by a second trained therapist with experience in manual therapy. Each group received seven minutes of the assigned treatment after the technique was explained to the subject. The technique was performed at a frequency of 0.5 Hz (with metronome control/steps) for two minutes and repeated three times, with 30 seconds of rest between each mobilization.

Neural Tensioner Technique Group

This group received a specific stretch to provide mechanical stress across the median nerve. This technique had two positions, start and end. It consisted of going from one to the other position constantly, maintaining a constant speed. In the start position, the subject was supine lying on a couch with the following parameters: contralateral cervical side bending, shoulder depression, shoulder abduction and external rotation to 90°, elbow flexion to 90°, and forearm supination (Figure 1A) [49]. In the final position, the therapist extended the elbow fully while maintaining the positions of all the joints as described above until the subjects felt tension (Figure 1B), then returning to the start position. The therapist monitored the subject to make sure they had no pain. In case of reported pain, the flexion of the elbow was adapted to nonpainful ranges.

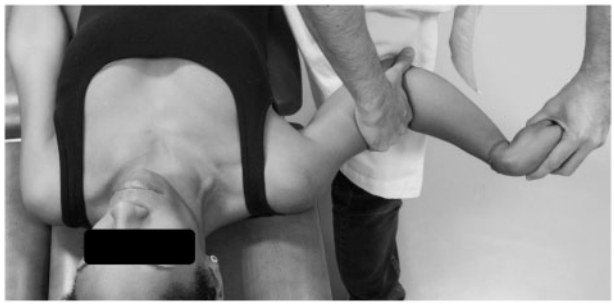

Figure 2. Sham technique. Only moving elbow flexion to extension and vice versa.

Sham Technique Group

The control group received an ST with minimal mechanical stress across the median nerve. Subjects were placed in neutral cervical spine position with no shoulder depression, shoulder abduction and external rotation to 45°, elbow extension to 45°, and forearm pronation (Figure 2). This ST was used previously in patients with carpal tunnel syndrome in a clinical trial [49]. This technique was passively repeated from elbow flexion to extension in the same way as the NTT group.

Sample Size

The CPM was chosen as the primary outcome measure. The effect size f was calculated using a pilot study, and the CPM outcome was calculated to be 0.25. Using the software G*power 3 [50], for analysis of variance (ANOVA) repeated measures, within–between factors, with a power of 0.95, and an alpha level of 0.05, a total of 54 subjects was estimated. Dropout rate was not taken into account because the study design was to evaluate the immediate effects.

Data Analysis

The statistical package SPSS 21.0 (SPSS Inc, Chicago, IL, USA) was used for analysis of all data. The

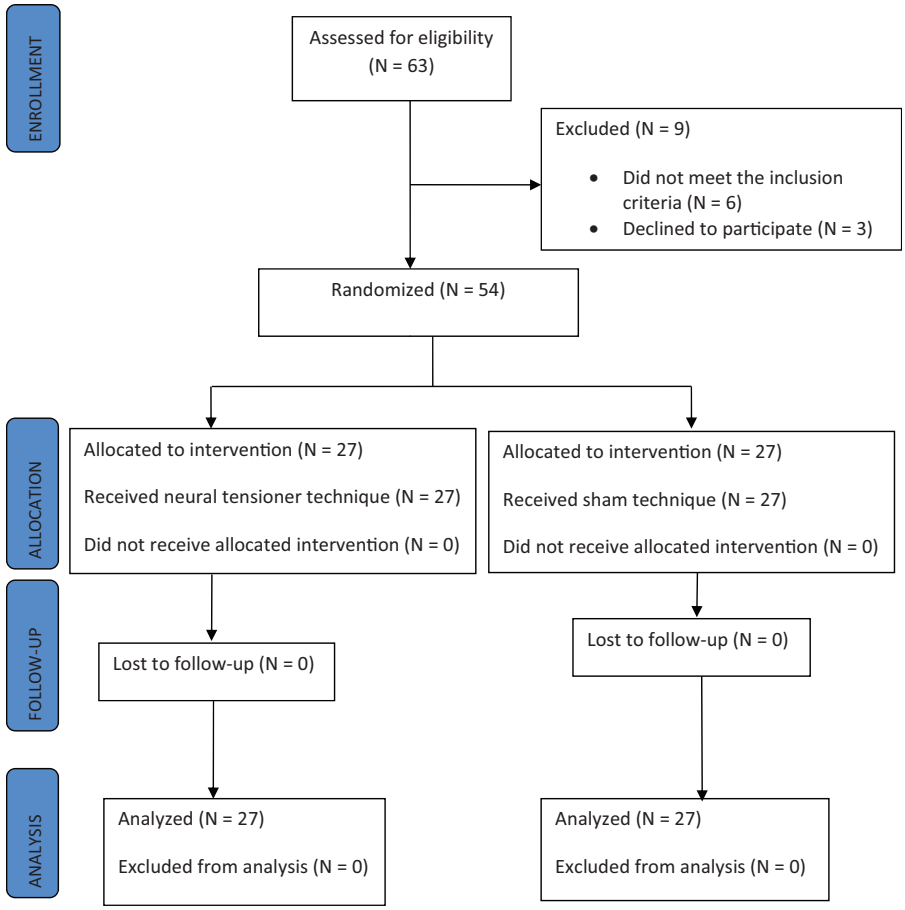

Figure 3. Consort flow diagram.

Kolmogorov-Smirnov test was used, and the entire sample had a normal distribution ($P > 0.05$). Descriptive statistics are presented as means ± SDs. For categorical variables, the chi-square test was used. Two-way repeated-measures ANOVA were used to compare continuous outcome variables. The factors analyzed were group (NTT group and ST group) and time (baseline and post-treatment). The time × group interaction, which tests the hypothesis of interest, was also analyzed. Partial eta-squared (η_p^2) was calculated as a measure of effect size (strength of association) for each main effect and interaction in the ANOVAs: 0.01–0.059 represented a small effect, 0.06–0.139 a medium effect, and >0.14 a large effect [51]. Post hoc analysis was performed in the case of significant ANOVA findings with Bonferroni correction for multiple comparisons between variables. Effect sizes (d) were calculated according to Cohen's method, in which the magnitude of the effect was classified as small (0.20–0.49), medium (0.50–0.79), or large (0.8) [52]. The α level was set at 0.05 for all tests, and the confidence interval (CI) was set to 95% [52].

Additionally, psychological variables and CPM were included as covariates in two-way repeated-measures analyses of covariance (ANCOVA) using the same 2×2 ANOVA model described above.

Results

Fifty-four subjects with chronic neck pain were included in this study. No subjects dropped out during the study; the flow chart of the subjects is represented in Figure 3. The mean± SD for age was 20.91 ± 2.64 years, and for duration of pain, it was 28.27± 24.92 months. There were no significant differences in sex, weight, or height between the study groups ($P > 0.05$); although a statistically significant difference was found for age ($P = 0.006$), the NTT group was older. All demographic characteristics between groups are presented in Table 1. VAS and cervical range of movement pre- and postintervention values are shown in Table 2.

The results of the ANOVA revealed a significant effect for the group × time interaction only for CPM ($F = 11.09$, $P = 0.002$, $\eta_p^2 = 0.176$). No significant main effects were found for the other measures (VAS [$F = 1.719$, $P = 0.195$, $\eta_p^2 = 0.031$], PPT C2 [$F = 0.731$, $P = 0.398$, $\eta_p^2 = 0.018$], flexion [$F = 0.176$, $P = 0.677$, $\eta_p^2 = 0.003$], extension [$F = 0.035$, $P = 0.852$, $\eta_p^2 = 0.001$], lateral flexions [$F = 0.422$, $P = 0.519$, $\eta_p^2 = 0.008$], and rotations [$F = 1.307$ $P = 0.258$, $\eta_p^2 = 0.024$]). Regarding the results of CPM, intergroup interaction differences were found postintervention

Table 1. Baseline participant characteristics

	NTT Group (N = 27)	ST Group (N = 27)	*P* Value
Age, y	21.83 ±3.16	19.93±1.43	<0.01*
Sex M/F (female %)	4/23 (85.2)	9/18 (66.7)	0.11
Duration of pain, mo	32.10±26.31	24.15±23.04	0.23
CPM, kg/cm^2	0.04 ±0.13	0.05 ±0.12	0.78
NDI, 0–50	10.31±5.22	10.33±3.60	0.9
VAS, 0–100 mm	45.2±20.9	34.8±18.2	0.06
CROM, grades			
Flexion	54.37±12.2	51.9±11.77	0.45
Extension	64.3± 12.61	61.19±10.95	0.33
Lateral flexion	83.61±13.98	82.1±11.21	0.66
Rotation	115.89±16.18	112.23±15.46	0.39
Psychological measures			
PCS, 12–84	12.60±9.25	13.40±8.15	0.73
TSK, 11–44	17.00±8.06	18.44±6.50	0.46
Anxiety state, 0–60	16.79±8.84	17.03±6.72	0.90
BDI, 0–63	6.41±4.46	6.55±3.56	0.89

Values are presented as mean ± standard deviation.

Beck = Beck Depression Inventory; CPM = conditioned pain modulation; CROM = cervical range of motion; NDI = Neck Disability Index; NTT = neural tension technique group; PSC = pain catastrophizing scale; ST = sham technique group; TSK = Tampa Scale of Kinesiophobia; VAS = visual analog scale.

*$P < 0.01$.

Table 2. Visual analog scale and cervical range of movement pre- and postintervention

	Group	Pre-intervention, Mean ± SD	Postintervention, Mean ± SD
VAS, 0–100 mm	NTT	45.2±20.9	31.7± 21.3
	ST	34.8±18.2	27.1±19.1
CROM, grades			
Flexion	NTT	54.36±12.20	52.66±10.16
	ST	51.90±11.76	49.41±11.07
Extension	NTT	64.29±12.61	63.51±10.82
	ST	61.18±10.94	60.83±10.58
Lateral flexion	NTT	83.60±13.97	85.28±14.27
	ST	82.09±11.20	82.22±12.12
Rotation	NTT	115.88±16.18	120.43±10.83
	ST	112.23±15.45	113.40±14.70

NTT = neural tension technique group; ST = sham technique group; VAS = visual analog scale.

($P = 0.002$) in favor of the NTT group, with a high effect size ($d = 0.98$); these results are presented in Table 3.

Conditioned Pain Modulation and Interaction with Psychological Factors

Repeated-measures ANCOVA did not show significant interaction between covariable and time for catastrophizing ($F = 1.556$, $P = 0.21$, $\eta_p^2 = 0.030$), kinesiophobia ($F = 1.654$, $P = 0.20$, $\eta_p^2 = 0.031$), anxiety ($F = 1.930$, $P = 0.17$, $\eta_p^2 = 0.036$), or depression ($F = 1.095$, $P = 0.30$, $\eta_p^2 = 0.021$). Descriptive data are presented in Table 1.

Discussion

The aim of this study was to determine the immediate effect of neural tensioner technique on endogenous analgesia mediated by CPM in subjects with chronic neck pain. Our results showed significant differences in CPM after treatment between NTT and ST groups, with a large effect size; the neural stretching enhanced CPM in patients with chronic neck pain. To the authors' knowledge, this is the first study that explores the influence of neural tensioner technique on CPM in patients with chronic neck pain, and our findings may contribute to a better understanding of the immediate effects of the technique. The literature clarifies that endogenous pain modulation is altered in subjects suffering from chronic pain [27,28]. Also, evidence shows positive findings in patients with osteoarthritis of the knee, in terms of improvement in endogenous pain modulation, when performing a surgical treatment [27].

Regarding the effects of physical therapy, evidence exists for enhanced CPM through different treatments such as TENS or manual therapy [20,53]. Furthermore, there is evidence for decreased temporal summation (improving pain modulation) after the mobilization of the median nerve in carpal tunnel syndrome [49]. Neurodynamic research with asymptomatic subjects showed that neural gliding and neural stretching produce a widespread hypoalgesic effect in comparison with placebo [23]. Besides, there is evidence that neural mobilization techniques provide immediate clinically relevant benefits with no evidence of harmful effects [54]. Our results are in line with recent research, as the NTT group demonstrated better outcomes. However, the pain intensity of the NP did not improve. The VAS mean of the NTT group was slightly higher than that of the ST (11.6 mm) group, and there were no statistically significant differences between groups; also, postintervention, both groups did not obtain statistical changes or clinically important differences (between 20.9 and 57.5) [55]. This may be related directly to the fact that the subject did not receive any technique on the cervical spine, just observable arm movement. This is in line with a recent study in which the neurophysiological effect only occurred in the experimental treatment group and not in the sham group [49]. Hence the authors can assume the sham technique was well conducted. Also note that better neurophysiological effect values were observed in the experimental group.

For cervical range of motion, no differences between groups were observed. This may be due to the fact that the technique was not focused directly on the cervical region joints, and the duration of the treatment was only seven minutes. In the literature, there have been no studies that have isolated the neural techniques used in the

Table 3. Mean and post hoc tests with Bonferroni correction for time × group interaction and time factor

	Group	Pre- intervention, Mean ± SD	Postintervention, Mean ± SD	Mean Difference (95% CI); Effect Size *d*
CPM, kg/cm^2	ST	0.05±0.12	0.01±0.09	0.039 (–0.24 to 0.102); 0.37
	NTT	0.04±0.13	0.15±0.18	0.106 (0.167 to 0.046)*; 0.7
	ST vs NNT postintervention			0.135 (0.054 to 0.216)*; 0.98

CI = confidence interval; CPM = conditioned pain modulation; NTT = neural tension technique group; ST = sham technique group.
*$P < 0.01$.

current study and also used the same measure of cervical ROM. Furthermore, a recent study reported changes in cervical ROM after a neural mobilization, but this study also included cervical traction for two weeks [56].

From a psychological point of view, the sample was homogeneous and there were no differences between groups. This adds further support to the validity of the study. Our results are supported by a recent meta-analysis showing that anxiety, depression, and pain catastrophizing levels may not be associated with a less efficacious diffuse inhibitory control system response [57]. Our outcomes differ from those of other studies, which have observed that the conditioning modulation can be enhanced by positive expectations and attenuated by negative expectations and increased stress levels [58,59]. Furthermore, Hermans et al. [59] concluded that younger age is related to better CPM. This could explain the results of our study because most of the subjects were young adults; therefore, psychological factors might not have played an important role in influencing the functioning of CPM.

This study had several limitations. First, the treatment involved only one single session, and there was no long-term evaluation; more sessions could provide more information regarding whether the CPM improvement remains over time. Second, the sample consisted of mostly young adults; for this reason, the results of this study cannot be extrapolated to all age groups, and future studies must focus on an older age state. Third, the CPM evaluation used was by tourniquet test for an economic reason. A research study conducted in 2012 comparing the ischemic-tourniquet test with the cold pressor test showed that the cold pressor test is a more reliable procedure [11]. Also, the authors did not take into account the expectations of the subjects, and according to a recent systematic review, this could influence the findings as they concluded that positive expectations are related to better conditioned pain modulation [59]. Finally, prolonged neurodynamic techniques seem to be more effective; therefore, the short duration of the treatment in this trial (seven minutes) could be a reason for not finding more significant outcomes [54]. Future research should consider these limitations. This research can be helpful for future studies that aim to evaluate the role of rehabilitation medicine approaches regarding the involvement of CPM in clinical practice.

Conclusions

This study suggests that neural tension technique enhances immediate conditioned pain modulation in subjects with chronic neck pain. The neural tension technique was not superior to the sham technique in improving immediate pain intensity and cervical range of movement.

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