ORIGINAL RESEARCH

Changes in Cervicocephalic Kinesthetic Sensibility, Widespread Pressure Pain Sensitivity, and Neck Pain After Cervical Thrust Manipulation in Patients With Chronic Mechanical Neck Pain: A Randomized Clinical Trial

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ABSTRACT

Objective: The purpose of the current randomized clinical trial was to examine the effects of cervical thrust manipulation or sham manipulation on cervicocephalic kinaesthetic sense, pain, pain-related disability, and pressure pain sensitivity in patients with mechanical neck pain.
Methods: Fifty-four individuals with neck pain were randomly assigned to receive either a cervical manipulation (right or left) or a sham manipulation. Immediate outcomes included cervical kinesthetic sense as assessed by joint position sense error (JPSE) and pressure pain thresholds (PPTs). At 1 week, neck pain intensity (numerical pain rate scale) and neck pain-related disability (Neck Disability Index [NDI]) outcomes were also collected.
Results: The mixed-model analysis of covariance revealed a significant group × time interaction in favor of the cervical thrust manipulation group for the JPSE on rotation and extension. There was also a significant interaction for changes in PPTs at C5 to C6 and tibialis anterior. At the 1-week follow-up, a significant interaction existed for neck-related disability but not for neck pain at rest, worst pain, or lowest pain experienced the preceding week.
Conclusions: Our results suggest that cervical spine thrust manipulation improves JPSE, PPT and NDI in participants with chronic mechanical neck pain. Furthermore, changes in JPSE and NDI were large and surpass published minimal detectable changes for these outcome measures. In addition, the effect sizes of PPTs were medium; however, only C5 to C6 zygapophyseal joint exceeded the minimal detectable change. In contrast, cervical thrust manipulation did not improve neck pain intensity at 1 week after the intervention. (J Manipulative Physiol Ther 2018;41:551-560)
Key Indexing Terms: *Neck Pain; Pain; Manipulation, Spinal*

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INTRODUCTION

Neck pain is a musculoskeletal symptom associated with disability and significant economic health costs.[1] Neck pain has been classified as 1 of the top 2 largest reasons for disability caused by musculoskeletal pain conditions by the Global Burden of Disease studies.[2] It has been reported that 70% of the general population will experience neck pain at some time during their lives; however, the global point prevalence is 4.9%.[3] In Spain, the 1-year prevalence of neck pain has been estimated to be 19.5% (95% confidence interval [CI]: 18.9-20.1).[4]

Mechanical neck pain leads to substantial disability,[5] reduced active cervical range of motion,[6] pressure pain hypersensitivity,[7] and greater joint position sense error (JPSE).[8] In fact, a meta-analysis conducted by Stanton et al observed a moderate standardized mean difference (0.44, 95% CI 0.25, 0.63) for JPSE between individuals with chronic neck pain and healthy participants.[9] Although the effectiveness of different exercise programs (ie, active joint repositioning, force sense, coordination, muscle performance, balance or unstable surface, and vibration training) on JPSE in participants with neck pain has been demonstrated; it is plausible that manual therapies can immediately enhance proprioception and may be a reasonable treatment approach to prepare a patient for exercise interventions.[10] The most updated Clinical Practice Guideline by the American Physical Therapy Association has recommended the use of cervical thrust manipulation for the management of neck pain guided by impairment- and function-related assessment of the cervical spine.[11] It is possible that cervical thrust manipulation may exhibit a positive influence on cervical sensory-motor control by enhancing the ability to reposition the head. A previous pilot study reported that participants with mechanical neck pain receiving cervical manipulation experienced a 41% improvement for head repositioning;[12] however, a small sample size, the lack of true randomization, and lack of blinding assessors were major limitations of this pilot trial.[12] Similarly, another study showed that chiropractic treatment, including cervical manipulation, proprioceptive neuromuscular facilitation, trigger point ischemic compression, and exercise, improved cervical kinaesthetic sensibility at the 5-week follow-up in patients with neck pain.[13] No randomized clinical trial has investigated the immediate effects of a single cervical thrust manipulation in JPSE in participants with mechanical neck pain. Therefore, the purpose of this randomized clinical trial was to examine the effects of cervical thrust manipulation or sham cervical manipulation on cervicocephalic kinaesthesia sense, pain, pain-related disability, and pressure pain sensitivity in individuals with mechanical neck pain. We hypothesized that patients receiving cervical thrust manipulation would exhibit greater improvements than those receiving the sham procedure.

Methods

Study Design

This randomized, single-blind, parallel-group trial compared the effects of a cervical thrust manipulation versus a sham cervical thrust manipulation in participants with neck pain. The primary endpoint was immediate changes in cervical kinesthetic sense assessed with the JPSE. Secondary outcomes included immediate changes in sensitivity to pressure pain (pressure pain threshold [PPT]) and changes at 1 week on neck pain intensity (numerical pain rate scale [NPRS]) and neck related-disability (Neck Disability Index [NDI]). This study was conducted following the Consolidated Standards of Reporting Trials extension for clinical trials.[14] The study design was approved by the ethics committee at Universidad Rey Juan Carlos, Madrid, Spain (URJC2015-161120155015), and the study protocol was prospectively registered (ClinicalTrials.gov: NCT02645630).

Participants

Consecutive individuals with bilateral neck pain presenting to their primary care physician and referred to physical therapy were screened for potential eligibility criteria. To be eligible, patients had to exhibit generalized neck–shoulder pain with symptoms provoked by neck postures, neck movement, or palpation of the cervical musculature with duration of at least 6 months. Individuals were excluded if they presented with any of the following criteria: (1) any contraindication to manipulation, for example, positive extension-rotation test;[15] (2) previous history of cervical trauma, that is, whiplash injury; (3) previous cervical surgery; (4) diagnosis of cervical radiculopathy or myelopathy; (5) fibromyalgia syndrome; (6) having undergone spinal manipulative therapy within the previous 6 months; or (7) less than 18 or greater than 65 years of age. Participants were informed about the study and signed the informed consent form before their participation.

Randomization and Allocation

Patients were randomly assigned to right cervical thrust manipulation, left cervical thrust manipulation, or sham cervical manipulation. Concealed allocation was performed using a computer-generated randomized table of numbers created before the start of the data collection by the epidemiological analysis of tabulated data. Individual and sequentially numbered index cards with random assignment were prepared, folded, and placed in sealed opaque envelopes. Blinded to the baseline examination, the therapist opened the envelope and proceeded with treatment according to group assignment. The examining assessor remained blinded to the patient's treatment group assignment.

Midcervical Spine Thrust Manipulation

The cervical thrust manipulation was applied by an experienced therapist with 12 years of clinical experience in treating patients with neck pain and with a certification in spinal manipulative therapy completed 8-years after their physical therapy degree. Both groups received the same cervical spine thrust technique applied to either the right or left side of the neck as allocated. The manipulation level in all patients was the midcervical segment (C3-C4).[16] For the right side (Fig 1), we used a high-velocity, midrange, left-rotation force to the right articular pillar of C3, on the right articular pillar of C4 with the patient in supine, with left rotation and right side-bending; for the left side, we used opposing movements.

The therapist used the manipulating hand to localize the targeted C3 to C4 segment, while the other hand cradled the head of the patient. Gentle ipsilateral side bending and contralateral rotation to the targeted side was introduced

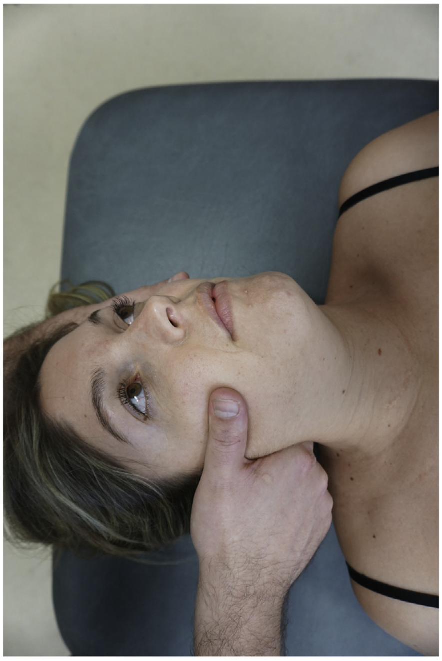

Fig 1. *Midcervical spine thrust manipulation applied to the C3 and C4 segment on the right side.*

until tension was perceived in the tissues at the contact point. Both hands performed a high-velocity, low-amplitude thrust directed up toward the patient's contralateral eye. If no popping sound was heard, the patient was not included in the analysis.

Sham Midcervical Spine Thrust Manipulation

A sham cervical manipulation following the principles described by Vernon et al[17] was conducted. The sham procedure consisted of the same degree of cervical side bending and rotation of the cervical spine with the manual support to the head or neck, as in the thrust manipulative procedure, but the thrusting force was applied outside of perceived tension. Therefore, no popping sound was heard on any sham procedure.

Cervical Kinaesthetic Sense

The primary outcome was cervical kinaesthetic sense, and it was assessed with the JPSE before and 15 minutes after each intervention by an assessor blinded to the treatment allocation of the participants. The JPSE test is based on the ability to relocate the natural head posture (anatomic position) after performing either active cervical extension or left and right rotations while blindfolded. In the current study, a laser pointer, mounted onto a lightweight headband, was used for data collection. The difference between the start and returning position of the laser beam on the target was recorded in degrees using the formula: angle = tan $^{-1}$ [error distance/90 cm]. We did not consider the positive and negative values (undershoot or overshoot of the target). Six trials were performed on each direction, and the mean was used in the main analysis.[18] Participants sat comfortably with their face 90 cm from the target. A support on their head held the laser pointer (50 g), and they made the cervical movement to be measured with their eyes open, as far as they were able. They then reaimed the laser pointer at the target and were asked to remember this position. Their eyes were then blindfolded with a mask, and they were asked to repeat the previous movement before reaiming at the center of the target to the best of their ability. Roren et al reported the laser method showed moderate (intraclass correlation coefficient: 0.68) test–retest reliability and an excellent correlation with an ultrasound technique for measurement of JPSE.[19] Dugailly et al found that an error of 4.5° can be considered a dysfunctional threshold and that the minimal detectable change (MDC) ranged between 0.44° and 0.63°.[20]

Pressure Pain Sensitivity

As a secondary outcome, pressure pain sensitivity was assessed before and 15 minutes after each intervention by an assessor blinded to the treatment allocation of the participants. An electronic pressure algometer (Somedic AB, Farsta, Sweden) was used to assess PPTs bilaterally over the C5 to C6 zygapophyseal joint and the tibialis anterior muscle. The PPT is defined as the minimal amount of pressure needed for the pressure sensation to first change to pain. The pressure was applied at a rate of 30 kPa/s. All participants were instructed to press a switch when the sensation changed from pressure to pain. The mean of 3 trials (intraexaminer reliability) was calculated and used for the main analysis. A 30-second rest period was allowed between each measure. The reliability of pressure algometry has been found to be high (intraclass correlation coefficient: 0.91).[21] The MDC for PPT over the neck and tibialis anterior muscle was found to be 47.2 and 97.9 kPa, respectively.[22]

Numerical Pain Rate Scale

An NPRS was used to determine the intensity of neck pain at baseline and 1 week after the intervention. Patients were asked to indicate the intensity of neck pain at rest, the worst and lowest level of pain experienced the preceding week, using an 11-point scale (0: no pain, 10: the worst imaginable pain) at baseline and 1-week after the intervention.[23] In individuals with mechanical neck pain, the minimal clinically important difference (MCID) for the NPRS has been estimated to be 1.3 points.[24]

Neck Disability Index

Neck related-disability was assessed using the NDI at baseline and 1 week after the intervention. The NDI is the

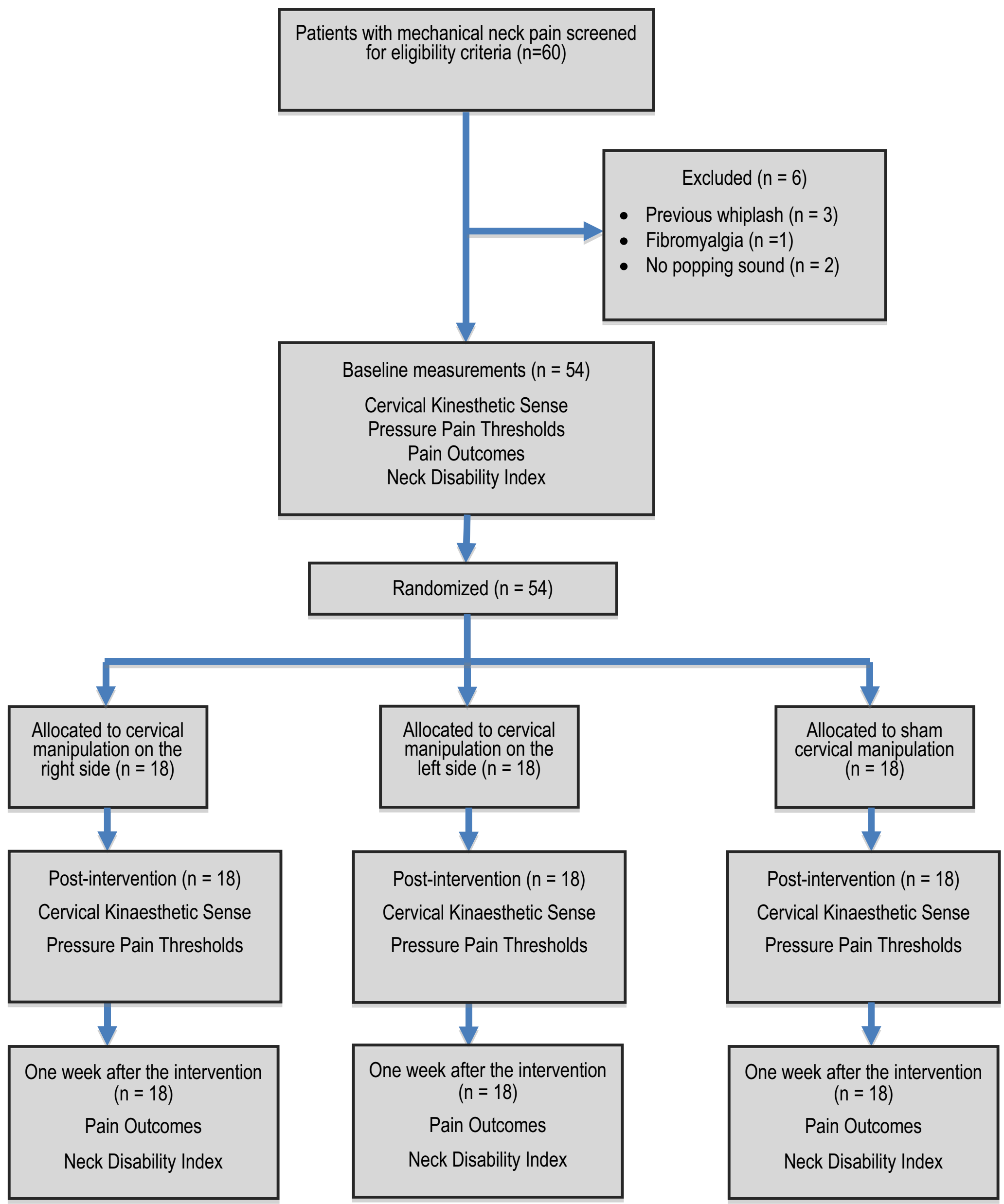

Fig 2. *Flow diagram of patients throughout the course of the study.*

most widely used instrument for assessing self-perceived disability in patients with neck pain.[25] The NDI consists of a self-report questionnaire with 10-items rated from 0 (no disability) to 5 (complete disability).[26] The numeric responses for each item are summed for a total score ranging between 0 and 50 points, where higher scores represent higher levels of pain-related disability. It has been reported that NDI exhibits excellent test–retest reliability, strong construct validity, strong internal consistency, and responsiveness in patients with mechanical neck pain.[27] The MCID for the NDI has been estimated to be 8 points (0-50) in individuals with mechanical neck pain.[28]

Treatment Side Effects

Patients were asked to report any adverse event that they experienced during the study. In the current study, an adverse event was defined as sequelae of 1-week duration with any symptom perceived as distressing and unacceptable to the patient and required further treatment.[29]

Sample Size Calculation

The sample size was calculated using Ene 3.0 software (Autonomic University of Barcelona, Barcelona, Spain). The calculations were based on detecting differences of 0.60° on

Table 1. *Baseline Demographics for the 3 Groups*

Outcome	Thrust on the Right Side	Thrust on the Left Side	Sham Thrust	F and *P* Values
Sex (male/female)	4/14	3/15	5/13	$\chi 2 = 0.643$; $P = .725$
Age (y)	35 ± 10	38 ± 7	39 ± 7	F = 1.269; *P* = .290
Duration of symptoms (y)	3.3 ± 1.1	3.3 ± 0.9	3.5 ± 1.1	F = 0.250; *P* = .780
Neck pain at rest (NPRS, 0-10)	2.7 ± 1.4	3.0 ± 2.2	2.6 ± 1.0	F = 0.410; *P* = .666
Worst pain experienced last week (NPRS, 0-10)	5.4 ± 2.3	5.4 ± 2.2	6.1 ± 1.7	F = 0.705; *P* = .499
Lowest pain experienced last week (NPRS, 0-10)	1.6 ± 2.1	1.2 ± 1.3	2.2 ± 1.4	F = 1.515; *P* = .229
Neck Disability Index (NDI, 0-50)	17.5 ± 9.4	17.2 ± 10.4	19.1 ± 7.6	F = 0.216; *P* = .806
Joint position sense error (deg)				
Cervical extension	5.3 ± 1.8	5.3 ± 1.9	5.1 ± 2.1	F = 0.099; *P* = .906
Ipsilateral rotation	4.1 ± 1.2	5.3 ± 1.8	5.0 ± 2.0	F = 1.620; *P* = .208
Contralateral rotation	5.3 ± 2.1	4.8 ± 1.5	5.2 ± 2.0	F = 0.800; *P* = .455
Pressure pain threshold (kPa)				
C5-C6 ipsilateral	240.3 ± 105.4	251.5 ± 104.0	231.6 ± 94.9	F = 0.100; *P* = .905
C5-C6 contra-lateral	230.0 ± 126.1	225.6 ± 95.2	217.5 ± 85.8	F = 0.469; *P* = .629
Tibialis anterior ipsilateral	442.5 ± 149.4	455.8 ± 119.2	407.0 ± 177.2	F = 0.523; *P* = .596
Tibialis anterior contra-lateral	461.6 ± 136.5	471.8 ± 124.0	400.8 ± 171.8	F = 0.610; *P* = .547

NDI, neck disability index; *NPRS*, numerical pain rate scale; *SD*, standard deviation.
Data are mean ± SD except for sex.

the main outcome (JPSE) at post-data,[20] assuming a standard deviation of 0.60°, an alpha level (α) of 0.05, and a desired power (β) of 80%. The estimated sample size was calculated to be of 18 participants per group.

Statistical Analysis

Data were analyzed using the SPSS version 20.0 (IBM Corp, Armonk, New York) statistical program. Means, standard deviation, and 95% CIs were calculated for each variable. The Kolmogorov-Smirnov test revealed a normal distribution of all quantitative data ($P < .05$). The normality and homogeneity criteria were checked for the dependent variables with kurtosis and skewness for normality and Levene's test for the homogeneity criteria. Baseline demographic and clinical variables among groups were compared using a 1-way analysis of variance for continuous data and χ^2 tests of independence for categorical data. No linear association, assessed by the Pearson correlation test, was found between the dependent variable and the remaining variables.

A 2 × 2 × 3 mixed-model analysis of covariance (ANCOVA) with time (before and after intervention) and side (ipsilateral, contralateral to the manipulative side) as within-participants factors, group (cervical thrust right side, cervical thrust left side, and sham thrust) as the between-participants factor, and sex as covariate, was used to examine the effects of the intervention on cervical rotation of the JPSE and PPTs. A 2 × 3 mixed-model ANCOVA, with time (before and after intervention) as the within-participants factor, group (cervical thrust right side, cervical thrust left side, sham thrust) as the between-participants factor, and sex as the covariate was used to determine the effects of the intervention on cervical extension of the JPSE, neck pain intensity, and pain-related disability. The effect size was calculated as the partial eta squared (η 2 p) when significant. An effect size of 0.01 was considered small, 0.06 medium, and 0.14 large.[30] The hypothesis of interest was the group × time interaction with a Bonferroni-corrected α of 0.017 (3 independent-samples *t* tests).

Results

Between January and November 2016, a total of 60 participants with neck pain symptoms were screened for

Table 2. *Preintervention, Postintervention, and Within-Group Change Scores for Neck Pain, Disability, and Joint Position Sense Error*

	Cervical Thrust on the Right		Cervical Thrust on the Left		Sham Thrust	
	Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention
Neck Disability Index (0-50)	17.6 ± 9.4	8.8 ± 9.5	17.2 ± 10.3	5.5 ± 9.0	19.1 ± 7.6	16.6 ± 6.6
Within-group change scores	-8.8 (95% CI -12.9 to -4.7)		-11.7 (95% CI -14.8 to -8.6)		-2.5 (95% CI -5.7 to 0.7)	
Neck pain at rest (NPRS, 0-10)	2.6 ± 1.4	1.2 ± 1.6	3.0 ± 2.2	1.7 ± 1.8	2.7 ± 1.0	2.1 ± 1.1
Within-group change scores	-1.4 (95% CI -2.5 to -0.3)		-1.3 (95% CI -2.3 to -0.3)		-0.6 (95% CI -1.4 to 0.2)	
Worst pain experienced last week (NPRS, 0-10)	5.4 ± 2.3	4.0 ± 2.4	5.4 ± 2.2	2.9 ± 2.5	6.1 ± 1.8	5.4 ± 1.1
Within-group change scores	-1.4 (95% CI -2.7 to -0.1)		-2.5 (95% CI -3.7 to -1.3)		-0.7 (95% CI -1.9 to 0.5)	
Lowest pain experienced last week (NPRS, 0-10)	1.6 ± 2.1	0.3 ± 0.6	1.3 ± 1.3	0.4 ± 1.1	2.2 ± 1.4	1.8 ± 1.4
Within-group change scores	-1.3 (95% CI -2.2 to -0.4)		-0.9 (95% CI -1.7 to -0.1)		-0.4 (95% CI -1.3 to 0.5)	
			Joint Position Sense Error (deg)			
Cervical extension	5.3° ± 1.8	3.1° ± 1.2	5.3° ± 1.9	2.9° ± 1.2	5.1° ± 2.0	5.5° ± 2.0
Within-group change scores	-2.2 (95% CI -3.0 to -1.4)		-2.4 (95% CI -3.2 to -1.5)		0.4 (95% CI -0.4 to 1.2)	
Ipsilateral rotation	4.1° ± 1.2	3.0° ± 1.7	5.3° ± 1.8	3.3° ± 1.7	5.1° ± 2.0	5.5° ± 2.4
Within-group change scores	-1.1 (95% CI -2.0 to -0.2)		-2.0 (95% CI -2.9 to -1.1)		0.4 (95% CI -0.5 to 1.3)	
Contra-lateral rotation	5.3° ± 2.1	3.3° ± 2.1	4.8° ± 1.6	2.7° ± 1.0	5.3° ± 2.2	5.5° ± 1.7
Within-group change scores	-2.0 (95% CI -2.9 to -1.1)		-2.2 (95% CI -3.0 to -1.4)		0.2 (95% CI -0.6 to 1.0)	

CI, confidence intervals; *NPRS*, numerical pain rate scale.
Data are means ± standard deviations for preintervention and postintervention and as means and 95% confidence intervals for within-group change scores.

eligibility criteria. Fifty-four (age: 37 ± 8 years; 22% male) satisfied all criteria, agreed to participate, and were randomly allocated to either cervical thrust right side (n = 18), cervical thrust left side (n = 18), or the sham thrust (n = 18) group. The reasons for ineligibility are shown in Figure 2, which provides a flow diagram of patient recruitment and retention. Baseline data among the groups were similar for all variables (Table 1). No adverse effect was reported by any patient.

The mixed-model ANCOVA revealed a significant group × time interaction for the JPSE on rotation (F = 15.325, $P < .001$, η 2 p: .231) and extension (F = 14.232, $P < .001$, η 2 p: .359). No significant side × time (F = 1.035, $P = .311$), group × side (F = 1.646, $P = .198$), and group × time × side (F = 0.517, $P = .598$) interactions were observed. Post hoc analyses revealed that both real thrust manipulation groups exhibited a greater decrease (large effect sizes) on JPSE in both cervical rotation and extension after the intervention as compared with the sham thrust group ($P < .001$) (Table 2). Sex did not influence the main interaction effect for cervical rotation (F = 0.349, $P = .702$) or cervical extension (F = 0.847, $P = .872$).

The 2 × 2 × 3 ANCOVA revealed a significant group × time interaction for changes in PPTs at C5 to C6 (F = 6.281, $P = .003$, η 2 p: .111) and tibialis anterior (F = 3.319, $P = .040$, η 2 p: .066): both cervical thrust manipulation groups exhibited greater bilateral increases (medium effect sizes) after the intervention than the sham thrust group (Table 2). The ANCOVA did not reveal any other significant interactions at C5 to C6 (side × time: F = 0.669, $P = .415$; group × side: F = 0.02, $P = .998$; group × time × side: F = 0.331, $P = .719$) and tibialis anterior (side × time: F = 0.142, $P = .707$; group × side: F = 0.119, $P = .888$; group × time × side: F = 0.014, $P = .986$). Sex did not influence the main interaction effects for C5 to C6 (F = 0.014, $P = .906$) and tibialis anterior (F = 1.166, $P = .283$). Table 3 provides baseline and postintervention data as well as within-groups differences and their associated 95% CIs for PPT data.

The 2 × 3 mixed model ANCOVA revealed a significant group × time interaction for pain-related disability (F = 8.285, $P < .001$, η 2 p: .253) but not for neck pain at rest (F = 1.014, $P = .370$), worst pain (F = 1.703, $P = .192$), or lowest pain (F = 1.150, $P = .325$) experienced the preceding week: both cervical thrust groups had a greater improvement in pain-

Table 3. *Preintervention, Postintervention, and Within-Group Change Scores for Pressure Pain Thresholds*

	Cervical Thrust on the Right		Cervical Thrust on the Left		Sham Thrust	
	Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention
C5-C6 ipsilateral	240.3 ± 105.4	312.9 ± 122.8	251.5 ± 104.1	314.9 ± 84.1	231.6 ± 94.9	233.7 ± 101.4
Within-group change scores	72.6 (95% CI 27.6-117.6)		63.4 (95% CI 18.3-108.5)		2.1 (95% CI -42.9 to 47.1)	
C5-C6 contra-lateral	230.0 ± 126.1	302.5 ± 132.9	225.6 ± 95.9	324.8 ± 109.2	217.5 ± 85.9	229.7 ± 109.4
Within-group change scores	72.5 (95% CI 27.4-117.6)		99.2 (95% CI 54.1-144.3)		12.2 (95% CI -32.9 to 57.3)	
Tibialis anterior ipsilateral	442.5 ± 249.1	516.2 ± 125.7	455.8 ± 119.2	533.4 ± 162.7	407.0 ± 177.2	409.1 ± 179.0
Within-group change scores	73.7 (95% CI 8.0-139.4)		77.6 (95% CI 11.9-143.3)		2.1 (95% CI -63.6 to 67.8)	
Tibialis anterior contra-lateral	461.6 ± 236.5	531.3 ± 195.3	471.9 ± 124.0	537.6 ± 128.6	400.0 ± 171.5	388.2 ± 156.1
Within-group change scores	69.7 (95% CI 4.0-135.4)		65.7 (95% CI 8.0-127.4)		-12.8 (95% CI -78.5 to 52.9)	

CI, confidence intervals.
Data are means ± standard deviations for preintervention and immediate postintervention and as means and 95% confidence intervals for within-group change scores. All data in kPa as measured with an algometer.

related disability 1 week after the intervention as compared with the sham thrust group (Table 2). A significant main effect for time in neck pain intensity was observed (all, $P < .05$): all groups exhibited similar decreases in the intensity of neck pain (Table 2). Again, sex did not influence the main interaction effects for neck pain at rest ($F = 1.784$, $P = .178$), worst pain ($F = 1.912$, $P = .173$), and lowest pain ($F = 0.001$, $P = .992$).

Discussion

The current randomized clinical trial suggests that the application of a cervical thrust manipulation targeted at the C3 or C4 resulted in improved cervical kinaesthetic sense, pressure pain sensitivity, and pain-related disability in participants with mechanical chronic neck pain immediately after treatment. In fact, the effect sizes for cervical kinaesthetic sense (JPSE) were large in both rotation and extension motions after the thrust manipulation and exceeded the MDC values of this outcome.[20] In addition, the effect sizes for changes in PPTs over C5 or C6 and tibialis anterior muscle were moderate and also exceeded the MDC for the cervical spine but not for the tibialis anterior.[22] Finally, the effect size for changes in pain-related disability was also large and surpassed the MCID[28] at 1 week after the real thrust manipulation.

The results of the current study relative to improvements in cervical kinaesthetic sense agree with previous studies investigating the effects of manual therapy. Palmgren et al randomized 41 participants with chronic neck pain to either chiropractic treatment or a control group and found that individuals in the treatment group exhibited significant improvements in cervical kinaesthetic sense.[13] However, because the chiropractic treatment included several interventions, it cannot be determined if the manipulation was the reason for the improvements in cervical kinaesthetic sensibility or if it was other therapeutic components. In addition, Rogers compared the effects of combined cervical and thoracic manipulation with a stretching program of the cervical muscles over 6 sessions and reported that the group receiving the thrust manipulations experienced greater improvements in cervical kinaesthetic sense than the group receiving muscle stretching.[12] Therefore, our trial is the first to demonstrate that a single session of cervical manipulation may be effective for improving cervical kinaesthetic sensibility in patients with mechanical neck pain and that the effects are not due to a placebo effect. Nevertheless, the identified effects were immediately after the intervention, so we do not currently know how long they will be maintained. It would be possible to consider that cervical spine manipulation could be performed as preparatory intervention before other strategies, that is, proprioceptive exercises, will be applied.

There are many physiological reasons as to how manipulation may exert its clinical effects, the majority of which are most likely neurophysiological in nature.[31] However, the exact reasons for the changes in cervical kinaesthetic sense remain to be elucidated, but a few possible hypotheses exist. It has been reported that receptors surrounding the facet joints and within the cervical musculature, particularly muscle spindles, are likely related to proprioception. Slosberg reported that dysfunctional articulations can potentially alter afferent input into the central nervous system, leading to altered proprioception.[32] It is also plausible that cervical manipulation may normalize nociceptive afferent discharge,[33,34] affecting the sensitivity of the muscle spindle, the main contributor to joint reposition sense,[35] and thereby enhancing cervical kinaesthetic sense. Finally, it is also possible that cortical and subcortical regions may be stimulated through somatosensory reflexes because of cervical manipulation and result in improved movement patterns.[36] Further scientific evaluation is necessary to determine if these hypotheses are accurate.

We also identified a significant hypoalgesic effect expressed by significant changes in PPTs at both C5 and C6 joint and tibialis anterior, in agreement with previous studies[37,38] and a meta-analysis.[39] It is possible that improvements in PPTs in the group that received cervical thrust manipulation may be directly related to an inhibition of neuroplastic changes within the dorsal horn that may contribute to sensitization.[40] In addition, it is possible that cervical manipulation may result in activation of segmental inhibitory pathways leading to improvements in PPTs.[41] This could potentially explain the improvements in PPTs at local segments, such as C5 and C6 joints, but we also found improvement in distant pain-free areas, such as the tibialis anterior. These widespread changes in pressure pain sensitivity may be the result of stimulation of descending inhibitory pain pathways.[42] Finally, it has also been proposed that manual therapy results on stimulation of the ventrolateral medulla potentially stimulating neurons associated with pain inhibition.[31]

We did not find significant differences on changes in neck pain intensity among the groups. Gross et al concluded that no clinical difference existed between cervical thrust manipulation and mobilization for the management of mechanical neck pain.[43] This result would lead to the hypothesis that clinical effectiveness of cervical manipulation is not related to the presence or absence of the audible popping sound. In fact, different studies have reported no relationship between the presence of audible pops during thoracic[44] and lumbar[45] spine thrust manipulation and clinically meaningful improvements in clinical pain outcomes. It is possible that the sham thrust intervention used in our study would also lead to some placebo effect.

The improvements found in pain-related disability at the 1-week follow-up are similar to numerous studies investigating the effects of cervical manipulation.[43] It may be that the associated reduction in pain described previously may contribute to an overall improvement in function. In addition to a hypoalgesic effect, it has been shown that manual therapy increases β endorphins[46] and reduces inflammatory mediators,[47] which might contribute to the overall improvements in function. A recent meta-analysis has confirmed the effects of spinal manipulation for inducing biochemical changes.[48]

Although the results of this study are encouraging, there are some limitations that must be considered. First, we only examined short-term effects, so we cannot be certain if these effects will be maintained in the long term. In addition, the same physical therapist performed all cervical manipulations, which may limit the generalizability of our findings. Second, we applied the cervical manipulation to a standardized level for practical reasons. We do not currently know if a more pragmatic approach, such as selecting the manipulating level according to symptoms or clinical findings, would lead to different results. Finally, we used a relatively small sample size. Future studies should include larger sample sizes and long-term follow-ups, including both physiological measures and patient reported outcomes, for better understating of sensory-motor effects of cervical manipulation.

Conclusions

Our results suggest that cervical spine thrust manipulation improves JPSE, PPT, and NDI in participants with chronic mechanical neck pain. In fact, changes in JPSE and NDI were large and surpassed published MDCs for these outcome measures. In addition, the effect sizes of PPTs were medium; however, only C5 to C6 joint exceeded the MDC. In contrast, cervical thrust manipulation did not improve the neck pain intensity at a week after the intervention.

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No funding sources or conflicts of interest were reported for this study.

Contributorship Information

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

Practical Applications

- A cervical spine thrust manipulation improved cervical kinesthesia sense in participants with chronic mechanical neck pain.
- A cervical spine thrust manipulation decreased pressure pain sensitivity in individuals with chronic mechanical neck pain.
- A cervical spine thrust manipulation improves pain-related disability but not pain intensity in participants with chronic mechanical neck pain.
- A cervical spine thrust manipulation may be used with other therapeutic strategies in the management of proprioception in patients with mechanical neck pain.

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