Immediate effects of three different upper trapezius trigger point techniques on pain intensity and pressure threshold in students with cervical pain: a randomized clinical trial

Jasemin Todri, Orges Lena *, Carolina Vázquez-Villa, Juan Martínez-Fuentes, Alberto Ciferri, María Antonia Murcia-González

Physiotherapy department, Universidad Católica San Antonio de Murcia UCAM, Spain

A R T I C L E I N F O

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A B S T R A C T

Objective: To compare the effectiveness of three manual therapy protocols (Jones, Lewit, and Chaitow) with a sham group in terms of pain pressure threshold and intensity.
Participants: Fifty-two physiotherapy bachelor students with neck pain lasting more than 3 days were recruited. Outcomes: Pain was assessed with Numerical Rating Scale and Pressure Algometer, while cervical range of motion was evaluated with the Baiobit Inertial sensor.
Intervention: An investigator, independent of the assessment and randomization, conducted all the interventions and sham procedures. Specifically, the Jones group received pincer palpation with a 1-min duration of ischemic compression, followed by 90 s of the no-pain Strain-Counterstrain technique. The Lewit group underwent flat palpation for 1 min, accompanied by 40 s of intermittent compression and post-isometric relaxation. The Chaitow group received deep palpation for 1 min, followed by the pressure release position lasting 20 s to 1 min, concluding with the muscle energy technique. The Sham group received only flat palpation and a 3-min homolateral muscle shortening position.
Results: Effects for all three techniques (Chaitow/Lewit/Jones) when comparing them to sham were not significant on pain intensity (−0.96/−1.01/−0.63) or on pressure threshold (−0.5/−0.4/−0.19). No adverse events or undesirable effects were observed during the study.
Conclusion: Immediate effects on pain intensity and pressure threshold are not directly attributable to any of the three tested trigger techniques.
Clinical trial registration number id: NCT05265468.

Implications for practice

1. The different protocols as Jones, Chaitow and Lewit lead for similar results in the active trigger point superior trapezius.
2. None of the studied techniques had any significant effect on pain over the sham treatment.
3. The positive changes observed might be explained by overall improvement in all groups over time and regression towards the mean, rather than by the specific techniques used.
4. Clinical improvements observed over time are unrelated to the technique used, so these observed changes do not necessarily indicate the success of trigger techniques.

1. Introduction

Neck pain is one of the most common musculoskeletal disorders [1]. Risk factors for this musculoskeletal problem include incorrect postures, sports activities, stress, occupational strain, and repetitive tasks [2,3]. The prevalence of neck pain is approximately 7.6 % [4,5], persisting in 75.7 % of the young population [6,7]. Experiencing an episode of neck pain is a predictor for developing nonspecific and chronic neck pain [8]. Trigger points are hyperirritable spots located within taut bands of skeletal muscle, causing pain upon palpation and stretching [9,10]. The literature primarily distinguishes between two types of trigger points: active and latent. Latent trigger points do not cause local or referred pain

* Corresponding author. ÍTEM-Innovation in Manual and Physical Therapies, Research Group, Physiotherapy Department, UCAM Universidad Católica San Antonio de Murcia, Campus de los Jerónimos, Nº 135 Guadalupe, 30107 Murcia, Spain.
E-mail address: lorges@ucam.edu (O. Lena).

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unless compressed, whereas active trigger points can cause pain even without compression [11]. Trigger points have the potential to refer pain to the neck area, contributing to symptoms in mechanical neck pain [9,12].

Various physiotherapy protocols exist for non-invasive treatment of trigger points, including Transcutaneous Electrical Nerve Stimulation (TENS), ultrasound (US), stretching, and deep friction massage [13]. Previous studies have compared electrotherapeutic treatments with manual therapy, but limited information is available regarding the relative effectiveness of different myofascial release techniques. Bron & Franssen [14] incorporated manual therapy into trigger point treatment techniques. Wendt & Waszak [15] explored two manual approaches: individual therapy and combination with other treatments. However, few authors have directly compared established protocols for trigger point treatment [16].

Several authors have explored various manual therapy methods for treating trigger points in the upper trapezius. These techniques include ischemic compression, which has shown moderate evidence for improving neck pain [16], as well as the Lewit protocol and Chaitow treatment [13–15]. The combination of different manual therapy procedures is commonly employed in both clinical practice and research. Iqbal et al. [17] reported better effects when combining the muscle energy technique with ischemic compression, compared to using the muscle energy technique alone, in terms of pain reduction and disability.

Therefore, it has been established that various manual techniques are effective in pain improvement. However, there is a lack of substantial scientific evidence comparing the outcomes of these different techniques. Nevertheless, to date, no randomized controlled trials have directly compared the effectiveness of the Chaitow, Lewit, and Jones protocols for the treatment of trigger points in the upper trapezius. Including a sham group allows for the control of placebo-related effects, enabling a clearer interpretation of whether observed changes can be attributed to the specific manual therapy protocols rather than nonspecific therapeutic factors. The aim of this study is to compare the efficacy of three manual treatment protocols (Chaitow, Lewit, and Jones) with a sham group in alleviating pain in individuals with cervical pain.

2. Methods

2.1. Trial design

This study was a monocentric, parallel, randomized controlled trial conducted to compare the immediate effects of three manual techniques Jones Strain-Counterstrain, Lewit Post-Isometric Relaxation, and Chaitow Muscle Energy Technique against a sham procedure for managing active myofascial trigger points (MTrPs) in the upper trapezius muscle. The trial adhered to the CONSORT guidelines and was preregistered on ClinicalTrials.gov (ID: NCT05265468). Ethical approval was granted by the Institutional Ethics Committee of the Catholic University of Murcia (CE112103). Participant recruitment took place from March to May 2022 [18].

2.2. Participants

Fifty-two physiotherapy undergraduates were recruited through in-class announcements. These students were selected due to their homogeneity in age, activity levels, and availability, which allowed for control over potential confounding variables and ensured protocol adherence, though this may limit generalizability to the broader population. Inclusion criteria were: (1) persistent neck pain or headache for more than three days and (2) at least one clinically active MTrP in the upper trapezius, as confirmed by a trained physiotherapist. The diagnostic criteria for active MTrPs followed the standard clinical protocol [10,13,14], including the presence of a taut band, hypersensitive spot, referred pain upon palpation, and a local twitch response. Exclusion criteria included dizziness or motion sensitivity, active infection, high emotional distress, or ongoing use of analgesics or muscle relaxants.

2.3. Study protocol

The evaluation of the active trigger point in the upper trapezius were done in sitting position in a practical physiotherapy class in a suitable temperature (23 °C ± 1 °C) [19] by a physiotherapist with 10 years experiences in the syndrome of myofascial pain who diagnosed and marked the active trigger point for the treatment. Also, a mobile application served as a musculoskeletal trigger points pattern map illustration (https://www.realbodywork.com/).

After the first evaluation, it was decided to treat only the active homolateral upper trapezius trigger point. Per protocol, the intensity of pain in the homolateral trapezius was compared with the contralateral side, and the side to be treated was selected based on the participant's reported pain intensity.

The diagnosis of myofascial trigger point was made through the analysis of the participants pain history accompanied by the physical examination asking for the most painful palpation using a single finger or more (depending on the trapezius volume of the participant). If the participant presented pain referred in the occipital, temporal, frontal bone, and headache then the active trigger point of upper trapezius was located.

2.4. Interventions

All the participants of the four study groups were positioned in sitting posture. The longer treatment technique had a duration of 90 s. In total one treatment per group had a 3.5-min duration. No repetition of the intervention was made in any of the groups. Three types of palpation: flat, pincer and deep were used in the study. Each group of treatment received a different palpation to localize the active trigger point of homolateral upper trapezius. The therapist also palpated the muscle belt in search of the taut band and hipertender trigger point following the muscle fiber direction. The participants of the four groups stayed in a muscle shortening position during the palpation. After that a trigger point compression was applied for the three intervention groups excluding the Sham group which does not receive any type of compression. The three types of compression used were: ischemic, intermittent and pressure release. All the techniques were synchronized with the deep respiration [25]. The outcomes were collected 10 min after each intervention.

Chaitow Group: Deep palpation for 1 min, followed by pressure release (20s–1 min) and a 2-min Muscle Energy Technique (MET) as per Chaitow's protocol, involving three phases with active contraction and stretching [26,27].

Lewit Group: Flat palpation for 1 min, followed by 40 s of intermittent compression and a 10-s isometric contraction against therapist resistance, finishing with post-isometric relaxation and muscle elongation [28,29].

Jones Group: Pincer palpation with 1-min ischemic compression, followed by a 90-s passive shortening in a pain-free position per the Strain-Counterstrain technique [30,31].

Sham Group: Received only flat palpation and 3 min of passive muscle shortening without any pressure or compression. Though minimally detailed previously, the sham procedure was designed to mimic the attention and duration of the active groups without delivering therapeutic input, thereby preserving blinding integrity.

2.5. Outcomes

2.5.1. Primary

Pain intensity was measured using the Numerical Rating Scale (NRS) [20], a validated 0–10 scale in which higher scores indicate greater pain

intensity. It is a reliable tool at both clinical and experimental levels, and has demonstrated sensitivity in assessing treatment effects.

Pressure pain threshold (PPT) was measured with Pressure Algometer (Wagner Instruments, Greenwich, Connecticut) [21,22] - is a reliable and valid instrument. To record the PPT, the algometer is placed vertically over the active trigger point of the upper trapezius and pressed on the surface of the body with increasing force at a constant rate of 1 kg/cm2. Participants are asked to report in time the pain sensation. The threshold (kg/cm2) is recorded on the screen of the algometer at the time of measurement. This procedure is repeated 3 times, at 30-s intervals, and the mean value is recorded as the participant's PPT.

2.5.2. Secondary

The range of movement was measured with Baiobit (BTS G-Walk) [23,24]- an inertial sensor for the evaluation of the space-time parameters of movements; reliable and valid. This wearable gait system is lightweight, portable, and easy to use. Another feature is that the system is used in different segments of the body: lumbar (S1-S2), shoulder, head, to measure the range of motion and work with upper limbs and back; as well as in the lower extremities. Concretely in this trial, using the appropriate belt, the Baiobit sensor was placed/positioned at the level of the occipital bone, above the external occipital protuberance. The movement selection for evaluation were: Flexion/Extension, Rotation, and lateral Banding. The record registered the cervical range of movement after the Bluetooth sensor activation and displayed the feedback in the portable computer monitor. All the movements of participants were saved.

The Baiobit sensor works with a magnetometer bandwidth up to 100 Hz, an accelerometer frequency bandwidth ranging from 4 to 1000 Hz, a sensor fusion up to 200 Hz and a gyroscope bandwidth ranging from 4 to 8000 Hz. The Baiobit sensor has inter-instrument correlation coefficient ranging between 0.90 and 0.99, and an intra-instrument coefficient of variation of $\leq$2.5 %, making it suitable for the assessment of physical activity with the same technical specifications of G-WALK (BTS Bioengineering, Garbagnate, Italy) [23].

The flexion/extension was the first range of movement to perform with a maximal cervical amplitude, accompanied with three repetitions and the pain experimented with NRS by participants for this movement as an option in the platform. The rotation was performed as the second range of cervical movement starting from the left to the right side with a maximal amplitude and three repetitions. Also, the NRS was reported by the participants for this movement as one option in the system range of movement calculation. Lateral bending or Inclination was performed as the last range of cervical movement, starting always from the left to right side inclination, meaning from the weak side, as for the majority the right-side dominant.

The mean of 3 repetitions for each movement was considered as the right value to analyze in this study. The difference between all the movements can be calculated and detailed by the sensor. Also, it has to be noticed that the total range of motion was calculated by the sensor, taking into account anthropometric characteristics for each participant with a different average. The sensor calculates the range of the movement in correlation with the age, height and weight; so, for each participant the average is different according to the anthropometric characteristics.

2.5.3. Adverse effect

Adverse effects were monitored by questioning participants throughout the evaluation and treatment periods. All interventions were conducted with the participant seated on a therapeutic bed, with the option to lie down if any adverse effects were experienced. If any participant was able to perceive dizziness/motion sickness or intensive headache; the treatment was going to be stopped. Also, all the participants were advised to send an email to the treating researcher during the first 48 h after technique implementation in case of experiencing any discomfort. Furthermore, for safeness, between assessments and treatment, the participant remained in the treatment room for a period of 60 min.

2.6. Randomization

Before the data collection, detailed information was given to all the students for the voluntary participation in a special tutoring class where all the necessary data were collected, and the eligibility criteria were explained. After collecting all primary data, an investigator independent of the assessment and intervention of the participants, carried out the randomization process. Patients were randomly allocated using block randomization in 1:1:1:1 ratio and the block size was fixed at four. Specifically, the participants had to select a codified group assignment card. The researcher noted for each one a coded sticker in the back that could only be identified by the physiotherapist in charge of the intervention. The physiotherapist was informed, referring to the four groups intervention codifications code, so that each treatment could be different without a problem. After finishing the treatment, the investigator removed the coded sticker and sent the patient for post-treatment assessment.

2.7. Blinding

Outcome measures were assessed at baseline and immediately after the intervention by two investigators who were blinded to the study group allocation. The participants were also blinded to the study group. So, the researcher noted for each one a coded sticker in the back that could only be identified by the physiotherapist in charge of the intervention. The physiotherapist was informed, referring to the four groups intervention codifications code, so that each treatment without a problem. The statistician remained blinded during both data preparation and analysis.

2.8. Statistical analysis

Sample size was calculated a priori using G*Power 3.1.9.2 software. A one-way fixed-effects ANOVA F-test was selected based on an expected medium effect size ($f = 0.25$; equivalent to Cohen's $d = 0.5$) for pain intensity, the primary outcome. With four groups ($n = 13$ per group), a significance level of $\alpha = 0.05$, power ($1–\beta$) of 0.80, and a numerator degree of freedom of 3, the required total sample size was 48 participants. An additional 4 participants were included to account for potential dropouts, resulting in a final sample size of 52. A change of 1.3 points on the NRS for cervical pain was considered the Minimal Clinically Important Difference (MCID), based on relevant literature.

Data were analyzed using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA) and are reported as means and standard deviations with corresponding 95 % confidence intervals (CIs). For the primary outcomes, ANCOVA was selected to adjust for baseline differences and improve the precision of estimated treatment effects. This approach was chosen over ANOVA to address concerns regarding potential initial group imbalances and to control for variability in pre-treatment values. The analytical model included all time points, but the primary hypothesis tested whether changes over time differed significantly between groups (i.e., the time $\times$ group interaction). Baseline values were included as covariates to account for individual variability but were not double counted in the model.

ANCOVA assumptions were systematically tested: homogeneity of regression slopes was confirmed, linearity and homoscedasticity were assessed through visual inspection of residual plots, and the normality of residuals was verified using the Shapiro-Wilk test. Partial eta-squared (η^2) values were reported to describe effect sizes. To enhance interpretability, absolute mean differences and their 95 % CIs were also presented, and comparisons to established MCID thresholds were included where applicable.

Given the exploratory nature of secondary outcomes, no Bonferroni

correction was applied, to avoid inflating Type II error rates. Furthermore, the reporting of secondary outcomes was streamlined to highlight that only cervical flexion showed a statistically significant between-group difference; other parameters are provided for completeness but are not over-interpreted.

The data was managed by one statistician not involved in the study. No missing data were reported.

3. Results

Sixty students with cervical pain were screened for eligibility criteria. Fifty-two satisfied the inclusion criteria and were randomized equally to the Chaitow Group (n = 13), Jones Group (n = 13), Lewit Group (n = 13), and Sham Group (n = 13). No dropouts were reported in the study (Fig. 1). Baseline data were similar across all four groups, with no significant differences in participant characteristics (Table 1). The total sample included 52 participants with cervical pain, with a mean age of 22.46 ± 4.76 years, weight of 74.54 ± 18.58 kg, and height of 175 ± 9.82 cm. The study included 24 females and 28 males (1.54 ± 0.50). Posture and study time were also evaluated for all participants. Table 1 reports the detailed baseline characteristics.

Repeated measures ANOVA for all the assessments indicated a significant pre-post difference over time between groups for the primary outcome NRS ($F = 24.655$, $p = 0.000$, $\eta^2 = 0.339$), and secondary outcomes including cervical flexion range ($F = 19.393$, $p = 0.000$, $\eta^2 = 0.228$), left side cervical rotation range ($F = 4.370$, $p = 0.042$, $\eta^2 = 0.083$), and right side cervical rotation range ($F = 4.512$, $p = 0.039$, $\eta^2 = 0.086$). No significant interaction was observed between groups and group*time, except in cervical flexion, where a significant group*time interaction was found ($F = 3.715$, $p = 0.018$, $\eta^2 = 0.188$) (Table 2).

Regarding primary outcomes, a statistically significant time × group interaction was observed for both pain intensity (NRS) ($F = 2.011$, $p = 0.045$, $\eta^2 = 0.432$) and PPT ($F = 2.121$, $p = 0.034$, $\eta^2 = 0.445$); however, the absolute mean differences between groups were small and did not exceed the MCID of 1.3 points for NRS or reach clinically meaningful thresholds for PPT. The largest NRS difference was 0.57 points (Jones vs. Chaitow), and for PPT, ~0.83 kg/cm^2 (Jones vs. Chaitow), with overlapping 95 % confidence intervals across all groups. Thus, despite statistical significance, the clinical relevance of these findings is limited.

Among secondary outcomes, only cervical flexion showed a between-group difference that may be considered clinically relevant ($F = 3.314$, $p = 0.002$, $\eta^2 = 0.556$), with the Jones group demonstrating the greatest improvement (mean = 56.40°), approximately 4.5° higher than the Sham group. While other ROM variables also reached statistical significance (all $p < 0.01$), their group differences were modest, effect sizes varied, and confidence intervals overlapped, suggesting limited clinical importance. These secondary findings are reported for completeness but interpreted with caution given their exploratory nature and absence of correction for multiple comparisons. Table 3 display a detailed statistical analysis.

4. Discussion

The aim of this study was to compare the efficacy of three manual treatment protocols (Chaitow, Lewit, and Jones) with a sham group in alleviating pain in individuals with cervical pain. The primary outcome

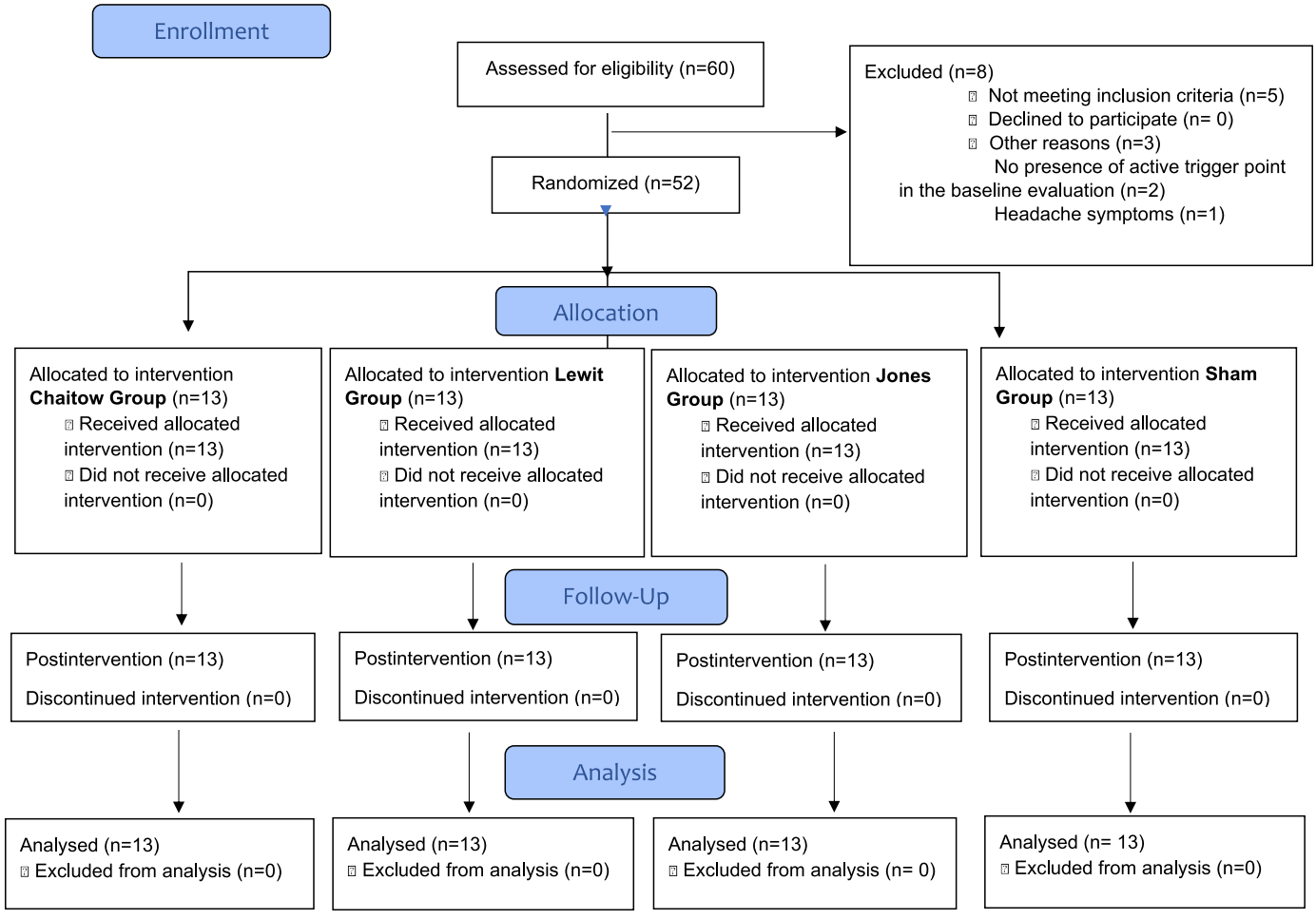

Fig. 1. Flowchart of participants.

Table 1
Participant's characteristics.

		Chaitow (n = 13)	Sham (n = 13)	Lewit (n = 13)	Jones (n = 13)	*p*
Gender distribution	Female (n = 24)	5	8	6	5	0.623
	Mean (SD)	1.62(0,51)	1.38(0.51)	1.54(0.52)	1.62(0.51)	
Study postures	Seated (n = 44)	11	9	11	13	0.223
	Lying Down (n = 2)	0	1	1	0	
	Seated and Lying Down (n = 6)	2	3	1	0	
	Mean (SD)	1.31(0.75)	1.54(0.87)	1.23(0.59)	1 (0.0)	
Study time (hours)		4.34 (2.61)	4.23(1,78)	4.53(1.85)	3.23(1.56)	0.604
Age (years)		23.46(5.92)	22.31(5.28)	22.08(4.66)	22(3.21)	0.859
Weight/cm		73.92(20.52)	74.13(16.64)	78(21.97)	72.13(16.34)	0.883
Height/kg		178.08(11.71)	171.23(7.24)	175.23(8.71)	175.46(10.89)	0.366

analysis showed no significant differences in pain intensity between the intervention groups and the sham group. Regarding the secondary outcome, cervical range of motion, only one statistically significant group-by-time interaction was found in cervical flexion. These findings suggest that, under the conditions of this study, none of the tested protocols demonstrated superior short-term effectiveness compared to sham treatment in terms of either pain reduction or cervical mobility. Moreover, when considering the minimum detectable clinical change for the NRS scale in patients with cervical pain—estimated at 1.3 points by Cleland et al. [32]—and for PPT, established at 0.63 kgf/cm^2 by Zicarelli et al. [33], the observed differences in this study do not appear to be clinically meaningful.

4.1. Trial results compared with other RCT

In other studies, manual therapy has been applied as a treatment for participants with trigger points in the upper trapezius. Wendt & Waszak [15] conducted a study comparing the compression trigger point technique with muscle shortening, muscle energy technique, and a combination of both. Although they observed improvements in pain and range of motion, no statistically significant differences were found between the treatment groups, consistent with our trial.

Similarly, Fernández de las Peñas et al. [34] analyzed the same variables to compare the results of a single intervention on subjects with latent or active trigger points in the upper trapezius. They applied ischemic compression in one group and transverse friction massage in the other. Despite using an algometer to assess pain pressure threshold (PPT) and the Visual Analogue Scale (VAS) for pain, their study did not reveal any significant changes between the two intervention groups.

The only difference observed in previous studies regarding the application of ischemic compression was whether the technique was applied in the lengthening [27] or shortening position. Surprisingly, no direct comparisons have been made between treatment protocols involving the techniques of Chaitow, Lewit, Jones, and a sham intervention. Most existing trials have instead compared some of the techniques included in these protocols with other treatment modalities [13,15,35,36]. Notably, some studies [13,36] have combined two techniques within at least one experimental group and have applied multiple sessions during the intervention. Although Yeganeh et al. [36] and Zutshi et al. [13] reported significant improvements in pain, cervical motion, and PPT in the combined treatment groups, no significant differences were observed between the various treatment groups. In a study by Saadat et al. [35], the combination of ischemic compression, Strain-Counterstrain, and muscle energy technique was applied to participants with active trigger points in the upper trapezius. The intervention group received a single session of this combined treatment, resulting in a statistically significant reduction in pain intensity compared to a no-treatment control group. This reduction was observed immediately after treatment and persisted 24 h later. However, no significant changes were detected between groups in terms of PPT. The divergent findings among these studies may be attributed to variations in the specific interventions performed. In our clinical trial and the study by Fernández de las Peñas [34], the ischemic compression technique was applied in isolation. In contrast, Saadat et al. [35] combined this technique with two others, thereby increasing the duration and intensity of treatment. Notably, while Fernández de las Peñas' study lacked a control or sham group, Saadat et al. included a control group but no sham group. These differences in study design may have contributed to different contextual effects observed in our research. Additionally, Wendt & Waszak [15] employed muscle energy techniques in combination with trigger point compression and shortening, resulting in improvements across all analyzed variables. When comparing our study with other research, several discrepancies emerged regarding the number of treatment sessions administered. Wendt & Waszak [15] and Yeganeh et al. [36] applied either one or three sessions, while Zutshi et al. [13] conducted eight treatment sessions in their experimental group. In our study, a single technique was performed once in each group, yet no significant changes were observed between the groups. These findings suggest that increasing the number of intervention sessions and combining various techniques may yield more substantial differences between groups.

Regarding cervical mobility outcomes, our clinical trial also demonstrated a significant increase in cervical flexion and extension movements within the Jones' group compared to the other treatment groups. In a study by Klein et al. [37], the effect of the Strain-Counterstrain technique was investigated in adults with cervical pain. This intervention was compared to a sham group, where participants were positioned in contralateral cervical rotation and maintained that posture for 90 s. The researchers assessed cervical motion using a Cervical Range of Motion (CROM) device. Interestingly, Klein et al. [37] did not observe significant changes in cervical mobility immediately after treatment. However, upon continued usual osteopathic treatment, a subsequent evaluation revealed an improvement in cervical mobility limitation. Comparing our results with Klein et al. 's study, we found better outcomes in cervical flexion and extension immediately after Jones' intervention. These findings suggest that exploring other manual therapy techniques may yield significant changes in cervical motion.

Some authors have also compared the conventional treatment protocol established by Jones with modifications based on clinical application. For instance, Meseguer et al. [38] aimed to analyze the immediate effects of the original Jones technique vs. a variation of the same technique. However, no significant differences were observed between groups in terms of pain and pain pressure threshold (PPT), except when compared to the control group. In our study, we observed a significant improvement in the Lewit group regarding left and right-side cervical rotation, as measured using the Baiobit sensor. Kashyap et al. [39] investigated cervical rotation in young females affected by trigger points in the upper trapezius. They utilized a flexible measuring tape to assess cervical mobility and evaluated PPT, pain intensity, and functional status. The interventions included active exercises and postural advice across all groups. Specifically, manual pressure release was applied in one group, while the other intervention group received muscle energy technique. However, despite these varied approaches, no statistical significance was found between the treatment groups [39]. In

Table 2
Differences between groups analysis over time.

Outcomes					Repeated measures ANOVA								
					Time			Time* groups			Groups		
Primary outcomes	***Groups***	Mean	Std. Deviation	N	F	*p*	*η2*	F	*p*	*η2*	F	*p*	*η2*
Pression algometer/pretest	Chaitow	6.8354	2.00513	13	1.843	0.181	0.037	0.102	0.959	0.006	0.373	0.773	0.023
	Control	6.8608	2.24652	13									
	Lewit	6.6215	2.05947	13									
	Jones	7.3700	2.93690	13									
	Total	6.9219	2.28867	52									
Pression algometer/post test	Chaitow	6.3338	2.65851	13									
	Control	6.1515	2.34631	13									
	Lewit	6.1885	3.45256	13									
	Jones	7.1823	3.00272	13									
	Total	6.4640	2.83983	52									
Numeric Rating Scale/Pretest	Chaitow	7.1931	0.49944	13	24.655	0.000	0.339	0.282	0.838	0.017	0.680	0.569	0.041
	Control	7.4477	0.81258	13									
	Lewit	7.4623	0.84149	13									
	Jones	6.8577	1.07528	13									
	Total	7.2402	0.84506	52									
Numeric Rating Scale Post/Test	Chaitow	6.2315	1.58963	13									
	Control	6.6685	0.91475	13									
	Lewit	6.4354	1.71373	13									
	Jones	6.2315	1.46688	13									
	Total	6.3917	1.42192	52									

	Outcomes					Repeated measures Anova								
						Time			Time* groups			Groups		
	Primary outcomes	Groups	Mean	Std. Deviation	N	F	p	η2	F	p	η2	F	p	η2
	Secondary outcomes (in degree)													
Baiobit Cervical Range of Movement	Cervical Flexion Pre test	Chaitow	49.92	8.500	13	19.393	0.000	0.288	3.715	0.018	0.188	0.546	0.653	0.033
		Control	52.69	6.969	13									
		Lewit	46.54	13.245	13									
		Jones	44.92	6.813	13									
		Total	48.52	9.480	52									
	Cervical Flexion Post test	Chaitow	54.69	9.638	13									
		Control	52.23	7.201	13									
		Lewit	51.92	10.356	13									
		Jones	55.08	6.626	13									
		Total	53.48	8.466	52									
	Cervical Extension PRE	Chaitow	51.69	7.123	13	0.027	0.871	0.001	1.734	0.173	0.098	0.379	0.768	0.023
		Control	58.85	13.801	13									
		Lewit	54.46	10.453	13									
		Jones	51.85	12.960	13									
		Total	54.21	11.425	52									
	Cervical Extension POST	Chaitow	53.31	7.387	13									
		Sham	53.85	10.057	13									
		Lewit	54.31	9.123	13									
		Jones	54.54	13.926	13									
		Total	54.00	10.103	52									
	Left Side Cervical Rotation/Pre test	Chaitow	63.69	8.430	13	4.370	0.042	0.083	0.344	0.794	0.021	0.767	0.518	0.046
		Control	63.54	11.110	13									
		Lewit	66.54	8.403	13									
		Jones	66.46	9.162	13									
		Total	65.06	9.179	52									
	Left Side Cervical Rotation Post test	Chaitow	65.00	7.257	13									
		Control	65.46	10.203	13									
		Lewit	70.46	7.031	13									
		Jones	67.92	11.146	13									
		Total	67.21	9.089	52									
	Right Side Cervical Rotation/Pre test	Chaitow	62.77	12.119	13	4.512	0.039	0.086	1.456	0.238	0.083	1.127	0.348	0.066
		Control	68.46	8.027	13									
		Lewit	59.62	12.901	13									
		Jones	65.31	7.554	13									
		Total	64.04	10.635	52									
	Right Side Cervical Rotation/Post test	Chaitow	65.15	7.777	13									
		Control	68.15	8.050	13									
		Lewit	65.92	5.469	13									
		Jones	66.77	9.842	13									
		Total	66.50	7.783	52									
	Left Side Cervical Inclination/Pre test	Chaitow	33.92	8.411	13	0.103	0.749	0.002	2.331	0.086	0.127	0.399	0.754	0.024
		Control	39.08	8.401	13									
		Lewit	37.69	7.674	13									

(*continued on next page*)

Table 2 (*continued*)

Outcomes					Repeated measures Anova								
					Time			Time* groups			Groups		
Primary outcomes	Groups	Mean	Std. Deviation	N	F	p	η2	F	p	η2	F	p	η2
Secondary outcomes (in degree)													
	Jones	36.77	9.884	13									
	Total	36.87	8.586	52									
Left Side Cervical	Chaitow	36.00	7.371	13									
Inclination/Post test	Control	36.77	6.673	13									
	Lewit	38.08	7.376	13									
	Jones	37.38	9.439	13									
	Total	37.06	7.591	52									
Right Side Cervical	Chaitow	32.85	6.926	13	0.081	0.777	0.002	0.622	0.604	0.037	1.199	0.320	0.070
Inclination/Pre test	Control	38.15	6.719	13									
	Lewit	37.08	8.558	13									
	Jones	38.69	9.827	13									
	Total	36.69	8.200	52									
Right Side Cervical	Chaitow	34.00	4.761	13									
Inclination/Post test	Control	36.92	7.599	13									
	Lewit	37.92	9.023	13									
	Jones	38.69	9.268	13									
	Total	36.88	7.843	52									

Table 3
Multivariate ANCOVA analysis with baseline data as covariance.

Outcome	Group	Mean	SD	n	95 % CI	F	p-value	Partial η^2	Observed Power	MCID
PPT	Chaitow	6.15	0.746	13	4.64–7.66	2.121	0.034	0.445	0.887	≥1.1 kg/cm^2
	Sham	6.271	0.771	13	4.71–7.83					
	Lewit	6.457	0.746	13	4.95–7.97					
	Jones	6.979	0.772	13	5.42–8.54					
NRS	Chaitow	6.089	0.378	13	5.32–6.86	2.011	0.045	0.432	0.865	≥2 points
	Sham	6.595	0.391	13	5.80–7.39					
	Lewit	6.225	0.378	13	5.46–6.99					
	Jones	6.659	0.391	13	5.87–7.45					
Cervical Flexion	Chaitow	53.331	1.99	13	49.30–57.36	3.314	0.002	0.556	0.987	≥10°
	Sham	51.855	2.056	13	47.69–56.02					
	Lewit	52.335	1.989	13	48.30–56.37					
	Jones	56.402	2.057	13	52.23–60.57					
Cervical Extension	Chaitow	55.965	2.279	13	51.35–60.58	3.824	0.001	0.591	0.996	≥10°
	Sham	49.943	2.356	13	45.17–54.72					
	Lewit	54.437	2.279	13	49.82–59.06					
	Jones	55.655	2.356	13	50.88–60.43					
Left Cervical Rotation	Chaitow	66.333	1.937	13	62.41–70.26	4.599	<0.001	0.635	0.999	≥10°
	Sham	65.961	2.002	13	61.90–70.02					
	Lewit	70.166	1.937	13	66.24–74.09					
	Jones	66.386	2.003	13	62.33–70.44					
Right Cervical Rotation	Chaitow	65.901	1.69	13	62.48–69.33	4.336	<0.001	0.621	0.999	≥10°
	Sham	67.189	1.747	13	63.65–70.73					
	Lewit	67.674	1.69	13	64.25–71.10					
	Jones	65.236	1.747	13	61.70–68.78					
Left Cervical Inclination	Chaitow	38.225	1.042	13	36.11–40.34	14.819	<0.001	0.849	1	≥5°
	Sham	35.194	1.077	13	33.01–37.38					
	Lewit	37.739	1.042	13	35.63–39.85					
	Jones	37.072	1.077	13	34.89–39.26					
Right Cervical Inclination	Chaitow	36.602	1.358	13	33.85–39.35	8.34	<0.001	0.759	1	≥5°
	Sham	35.043	1.403	13	32.20–37.89					
	Lewit	38.439	1.357	13	35.69–41.19					
	Jones	37.454	1.404	13	34.61–40.30					

our trial, Chaitow's group demonstrated a significant improvement in left and right-side inclination compared to other groups. Choksi et al. [40] evaluated lateral cervical flexion and pain in subjects with cervical pain. They compared deep transverse massage, ischemic compression, and sham conventional therapy, observing a significant improvement in all groups, but no differences between the groups. Gemmell et al. [41] compared the effect of ischemic compression with sham ultrasound in a group of chiropractic students with active trigger points in the upper trapezius. They evaluated the range of lateral cervical flexion using a goniometer and found no significant differences between groups. Unlike these studies [40,41], our trial utilized the Baiobit sensor to measure cervical motion, providing a more accurate and reliable tool for analyzing the active mobility of the cervical spine [25].

4.2. *Limitations and future studies*

One limitation of this study lies in the application of a single treatment session. However, in other research studies with a higher number of sessions, no significant differences were observed between groups when comparing various treatment protocols for trigger points with

sham treatment. Nevertheless, applying only one session may have limited the ability to detect cumulative or sustained treatment effects, which are often observed with repeated interventions in clinical practice. Another limitation pertains to the sample size, which was not calculated to exclude MCID in pain. Consequently, the study may be underpowered to completely rule out any clinically significant effects. Notably, our study sample consisted of physiotherapy students, which may limit the external validity of the findings and reduce generalizability to broader clinical populations with different demographic or clinical characteristics. Additionally, lack of follow-up with participants may impact the generalizability of results to other populations with neck pain, and it remains uncertain whether the effects observed persist beyond the intervention period. For future investigations, increasing the number of treatment sessions and incorporating a control group without intervention would be informative. Future trials should also consider multi-session protocols with follow-up assessments to determine the duration and stability of treatment effects over time. Furthermore, elucidating the expected mechanisms of intervention and exploring ways to enhance them would yield more conclusive insights into the effects of different trigger point treatment modalities. In our trial, the possibility of multiple testing influencing results should be acknowledged. Interestingly, our study revealed significant effects related to left cervical rotation and side-bending restrictions, likely due to random bias.

4.3. Conclusion

None of the three protocols (Chaitow, Lewit, and Jones) have demonstrated superiority over the sham group in improving pain intensity and PPT.

CRediT authorship contribution statement

Jasemin Todri: Writing – original draft, Supervision, Methodology, Data curation, Visualization, Software, Investigation, Conceptualization, Writing – review & editing, Validation, Resources, Formal analysis. **Orges Lena:** Visualization, Software, Methodology, Data curation, Writing – review & editing, Validation, Resources, Investigation, Conceptualization, Writing – original draft, Supervision, Project administration, Formal analysis. **Carolina Vázquez-Villa:** Writing – original draft, Data curation, Writing – review & editing, Supervision. **Juan Martínez-Fuentes:** Writing – review & editing, Project administration, Writing – original draft, Funding acquisition, Resources, Data curation. **Alberto Ciferri:** Supervision, Methodology, Validation, Data curation. **María Antonia Murcia-González:** Visualization, Methodology, Writing – review & editing, Validation, Data curation, Writing – original draft, Supervision.

Ethical approval

This study was approved by the Ethics Committee of the Catholic University of Murcia “San Antonio" with protocol No. CE112103.

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Declaration of competing interest

The authors have no conflict of interest to report.
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