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Comparative short-term effects of two thoracic spinal manipulation techniques in subjects with chronic mechanical neck pain: A randomized controlled trial

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Abstract

Spinal Manipulation (SM) has been purported to decrease pain and improve function in subjects with non-specific neck pain. Previous research has investigated which individuals with non-specific neck pain will be more likely to benefit from SM. It has not yet been proven whether or not the effectiveness of thoracic SM depends on the specific technique being used. This double-blind randomized trial has compared the short-term effects of two thoracic SM maneuvers in subjects with chronic non-specific neck pain. Sixty participants were distributed randomly into two groups. One group received the Dog technique (n = 30), with the subject in supine position, and the other group underwent the Toggle-Recoil technique (n = 30), with the participant lying prone, T4 being the targeted area in both cases. Evaluations were made of self-reported neck pain (Visual Analogue Scale); neck mobility (Cervical Range of Motion); and pressure pain threshold at the cervical and thoracic levels (C4 and T4 spinous process) and over the site described for location of tense bands of the upper trapezius muscle. Measurements were taken before intervention, immediately afterward, and 20 min later. Both maneuvers improved neck mobility and mechanosensitivity and reduced pain in the short term. No major or clinical differences were found between the groups. In the between-groups comparison slightly better results were observed in the Toggle-Recoil group only for cervical extension ($p = 0.009$), right lateral flexion ($p = 0.004$) and left rotation ($p < 0.05$).

1. Introduction

Non-specific neck pain (NSNP) is defined as cervical pain without pathogenic and/or pathognomonic signs and symptoms (Childs et al., 2008). It is a common disorder, and may be affecting up to 46e54% of the population (Côté et al., 2000). Also, it has been described as a significant predictor of sickness absence (Kääriä et al., 2012).

It has been suggested that there is no active treatment distinctly superior to any other in the intervention of neck pain (NP) and its associated disorders (Hurwitz et al., 2008; Huisman et al., 2013).

With regard to manual therapy, there is moderate quality evidence to support that high-velocity thrust manipulation produces similar positive effects as slow, non-thrust mobilization for pain reduction, patient satisfaction and function improvement in NSNP (Gross et al., 2010).

Spinal manual therapy has been linked with positive changes on pain central processing mechanisms, probably through the stimulation of areas within the central nervous system (Schmid et al., 2008). SM is thought to modify motorneuron excitability (Pickar, 2002) and release tension from the sensitized pathways (Hernández Xumet, 2009). The decrease in nociceptive inputs after SM may positively affect nociceptionemotor control interactions (Nijs et al., 2012).

Even though cervical SM has been shown to have positive effects on NP (Mansilla-Ferragut et al., 2009; de Camargo et al., 2011), techniques, such as increased neck pain, headaches, and transient neurological symptoms (Ernst, 2007; Carlesso et al., 2010). But when considering the correlation between NP and restricted mobility in the thoracic spine (Childs et al., 2008), the use of thoracic SM (TSM) has been recommended in individuals with cervical pain (Childs et al., 2008). Positive results in pain relief, neck function, and cervical posture have been reported after TSM (Lau et al., 2011; Puentedura et al., 2011; Ferreira et al., 2013). However, there have been few high quality randomized controlled trials (Gross et al., 2010), which makes difficult to draw definitive clinical conclusions (Cross et al., 2011).

There has been progress recently to develop clinical prediction rules to identify those NP subjects who are more likely to benefit from SM (Cleland et al., 2007a; Saavedra-Hernández et al., 2011). It still remains uncertain which technique is the most effective (Gross et al., 2010). Previous attempts have been made to compare the impact of two SM procedures in subjects with low-back pain (Sutlive et al., 2009). Also, previous studies have compared the effectiveness of TSM versus cervical SM, with or without articular thrust (Puentedura et al., 2011; Masaracchio et al., 2013). However, it has not yet been proven whether or not the effect of TSM depends on the specific technique being used. Therefore, the objective of this study has been to evaluate the immediate and short-term effect of two TSM techniques of high-velocity low-amplitude on functionality of the cervical region, and to compare the differences in outcomes between both techniques.

2. Materials and methods

2.1. Study design

A controlled, randomized, and double-blind clinical trial was carried out. The project was approved by the Institutional Review Board and has been registered in the

Australian and New Zealand Clinical Trial Registry with registration number ACTRN12613001000796.

2.2. Randomization

The random sequence was obtained using a randomized number table designed by an external office (www.randomizer.org). An outside collaborator safeguarded the sequence from those participating in the study. The therapist in charge of the treatment was informed of the group allocation of every subject through a sealed opaque envelope.

2.3. Blinding

Each participant received general information about the research (possible risks and benefits) and the ethics aspects related to it. Before randomization, participants were told that a single intervention would be performed. Subjects and evaluators who collected or analyzed data remained unaware of the aims of the study and the treatment allocation group, to ensure participant blinding and outcome assessor blinding respectively (Chess and Gagnier, 2013). The clinician performing the TSM techniques did not participate in the assessment protocol.

2.4. Sample size

Sample size calculation was made taking into account a one-tailed hypothesis (subjects in both groups were expected to improve), an allocation ratio between-groups of 1:1, a large effect size (d = 0.8), an alpha value of 0.05 and a 90% power (Gpower 3.1.2®, Kiel University, Germany). Twenty-eight subjects per group were necessary to complete the study.

2.5. Participants

Subjects with a medical diagnosis, by a consulting physician, of chronic NSNP, with or without pain radiating to the head, trunk and/or limbs (Guzman et al., 2008), were selected from the database of the principal researcher's clinic. Of 73 individuals who responded to the invitation, 9 were excluded (Fig. 1 - flowchart). Sixty-four subjects between 18 and 60 years (37 ± 10.33) were randomly distributed in two groups. Four subjects were excluded from the analysis phase (Fig.1). The study was conducted according to the ethical principles of the Helsinki Declaration. The data collection took place for 5 months (May - September 2012).

The inclusion criteria were: (a) aged between 18 and 60 years; (b) a minimum of a 3-month history of NSNP (Lin et al., 2013). No minimum intensity of painwas specified; (c) NP not to be due to any known cause, such as fracture or infection (Côté et al., 2008); (d) cervical pain was present with increased pain on one of the following criteria; with maintained posture, with movement and/or with palpation of the spinal muscles; and (e) perceived discomfort with joint pressure (van Schalkwyk and Parkin-Smith, 2000). Criteria for exclusion were: (a) current use of any medication which might interfere with SM; (b) the presence of any inflammatory disease (Côté et al., 2008); (c) any neurological conditions; (d) any bone pathology or history of tumors; (e) whiplash injury; (f) having received SM in the previous 2 months (Lau et al., 2011); (g) two or more positive signs of compressed nerves (changes in sensation, myotomal weakness in the arms, or alteration in deep tendon reflexes) (Puentedura et al., 2011); (h) previous spinal surgery; (i) any contraindication to SM (González-Iglesias et al., 2009a); and (j) subjects who did not achieve cavitation after two thrust attempts.

2.6. Evaluators

A physiotherapist with 9 years experience and who had received training in the assessment tools, performed the evaluations before the intervention, immediately afterward, and in the short term (20 min after intervention). The treatment in both groups was carried out by another physiotherapist with 8 years experience in the use of SM techniques (interventionist training) (Chess and Gagnier, 2013).

2.7. Outcome measures

2.7.1. Pressure algometry

The pressure pain threshold (PPT) is the minimum amount of pressure needed to evoke discomfort or pain (Fischer, 1987). To measure PPT, an analogue pressure algometer (Baseline , FEI Inc., White Plains, NY, USA) was used. With the subject seated, PPT was assessed over the spinous process of the fourth cervical and thoracic vertebrates (C4 and T4), and over the area described for the location of tense bands in the upper trapezius (UT) muscle (Travell et al., 2001). The mean of three measurements was taken as the reference value (Heredia-Rizo et al., 2013). Pressure algometry has proven to be valid and has a high inter-examiner reliability, 0.91 (95% CI 0.82e0.97) (Chesterton et al., 2007). The minimum detectable change (MDC) to report a true difference in the UT muscle in subjects with NP has been determined in 47.2 kPa . 0.48 kg/cm2 (Walton et al., 2011).

2.7.2. Cervical mobility

Cervical mobility was measured using the Cervical Range of Motion Basic (CROM-device®) tool (Performance Attainment Associates, St Paul, MN, USA) (Youdas et al., 1991). The participant was seated with no back support and both feet on the ground (Wibault et al., 2013). Measurements were taken in the following order: flexion, extension, right and left lateral flexion and rotation.

The CROM-device® has been shown to have a high inter-examiner reliability (Capuano-Pucci et al., 1991). It is easy to use and requires only one evaluator (Mokkink et al., 2010). The standard error of measurement across all cervical movements range from 1.6º to 2.8º, while the MDC range from 3.6º (right lateral flexion) to 6.5º (flexion) (Audette et al., 2010).

2.7.3. Self-perceived neck pain

NP was assessed with a Visual Analogue Scale (VAS). The VAS is considered to be an effective, sensitive, easy to use, and reproducible method to assess acute and chronic pain (Carlsson, 1983), and to detect immediate and clinically relevant changes in pain perception (Bird and Dickson, 2001). The subject was asked about the current level of pain in rest position.

2.8. Interventions

A single TSM manoeuverwas performed in each participant. The estimated time for intervention was about 2 min in each group.

2.8.1. Dog-technique group (DTG)

The dog technique was performed as previously described (Sánchez-Jiménez and Rodriguez-Díaz, 2009; Dunning et al., 2012), T4 being the targeted vertebrae (Fig. 2). The subject was in supine position with arms across the chest. The therapist's right hand contacted bilateral transverse processes of T4. The other hand was placed against the subject's elbows and added flexion and posterior slide movements to reduce the slack. The space inferior to the xiphoid process of the therapist was used as the contact area against the patient's elbows. A high-velocity low-amplitude thrust was delivered in the anterior-posterior direction as the subject exhaled.

2.8.2. Toggle-recoil group (TRG)

The toggle-recoil technique has been described as quite common in clinical practice (Graham et al., 2010). With the participant lying prone, the technique was performed as modified by McTimoney (Colloca et al., 2009). The therapist crossed his forearms and contacted the transverse processes of T4 with the pisiform bones to ensure a specific contact. While the subject breathed out, the therapist delivered a posterior-anterior impulse to achieve the articular thrust (Fig. 3).

2.9. Data analysis

The statistical package PASW Advanced Statistics 18.0 (SPSS Inc., Chicago, USA) was used to analyze the data. The analysis was conducted considering statistically significant a p-value <0.05. Normality of the study variables was assessed with the Kolmogorov-Smirnov test. The results are expressed as the mean with the corresponding standard deviation and/or 95% confidence intervals (95% CI), or as percentage frequencies. Between-groups comparison for baseline data was made with the Student's t-test for independent samples for quantitative variables with normal distribution (age, height, weight, VAS, PPT and cervical mobility), the U-Mann Whitney for quantitative data with no normal distribution (left lateral flexion and left rotation) and the chi-squared (c2) test for qualitative variables (sex and handedness). The inferential analysis of variance for repeated measures (ANOVA or Friedman tests) with the group and with the time allowed the inter-group differences to be analyzed.

Results

3.1. Baseline measurements

The study variables followed a normal distribution ($p > 0.05$), except for left lateral flexion ($p = 0.025$) and left rotation ($p = 0.037$). Table 1 lists the baseline characteristics of the participants. The only baseline difference was found for right rotation ($p = 0.009$).

3.2. Intra-group comparison

Table 2 provides the intra-group comparison of score changes in the outcome measures. Data are reported as the difference between final and baseline values. Therefore, negative values of score changes after intervention indicate a decrease in the outcome variables.

In regard to the PPT, mechanosensitivity values significantly improved after intervention in both groups, except for the right UT in the DTG ($p = 0.062$). As Table 2 depicts, there were slightly better results in the TRG, especially in T4, with a score change of 0.70 kg/cm2 (0.99/0.40).

With regard to self-perceived NP, statistical significance was found in both groups immediately after intervention and in the short term ($p < 0.001$). The findings were especially relevant for pain relief in the TRG in the short term ($p < 0.001$; $F_{1,29} = 50.56$; R2 = 0.63).

Cervical mobility increased in the TRG in all directions ($p < 0.005$). The best results in this group were found for left rotation ($p < 0.001$; F1,29 . 35.62; R2 . 0.55). On the contrary, in the DTG, there were no significant changes for cervical flexion ($p = 0.053$), and lateral flexion movements (right lateral flexion, $p = 0.740$; and left lateral flexion, $p = 0.288$).

3.3. Inter-group comparison

Table 3 reports the between-groups comparison of the score changes after intervention. All outcome variables showed better results in the subjects who underwent the toggle-recoil technique. No statistical significance was found for NP or mechanosensitivity ($p > 0.005$). Referring to cervical range of motion (ROM), results showed significant differences only for neck extension immediately after intervention ($p = 0.009$), right lateral flexion in the short term ($p = 0.004$) and left rotation post-intervention (p =

0.014) and in the short term ($p = 0.001$); the biggest difference observed being for left rotation in the short term, with a small effect size ($p = 0.001$; $F_{1,58} = 12.96$; $R2 = 0.18$).

Discussion

Summary of findings

Both TSM techniques improved neck mobility, pain and mechanosensitivity, with statistical intra-group significance in all outcome variables only for the TRG. The study showed no major or clinical differences between-groups, except for slightly better results in the TRG for left rotation, extension and right lateral flexion.

4.2. Strengths of the study

To the authors' knowledge, this is the first trial to compare the efficacy of two different TSM manoeuvers in subjects with NP, by means of objective (PPT and CROM) and subjective (VAS) assessment tools. No previous study has used PPT as an outcome measure after TSM in chronic NSNP.

4.3. Changes in self-perceived pain

One of the possible reasons to understand the impact of TSM on pain relief in NP subjects has been the principle of regional interdependence. This principle offers the explanation that the subject's pain may be related to a restriction in a proximal or a distal anatomical area, (Wainner et al., 2007) which may support the present observations.

A clinical prediction rule was developed to predict those NP patients who are likely to benefit only from TSM (Cleland et al., 2007a). According to this, a decrease of 2.2 points (46% improvement) in the Numeric Pain Rating Scale (NPRS) was found in the group with successful results. A comparable pattern emerges from this study. The score change in the VAS meant a 43.82% improvement immediately after intervention and a 67.76% improvement in the short term, considering the whole sample. A comparison between-groups in the short term reveals that the results were slightly better in the TRG (72.26% versus 63.45% in the DTG). However, the improvement did not surpass in any case the MCD reported for the NPRS (2.1 points) (Cleland et al., 2008).

Similar findings have been concluded after combining cervical and TSM (Saavedra-Hernández et al., 2011), TSM with infrared radiation therapy and educational advice (Lau et al., 2011), and when comparing thoracic mobilization and manipulation with or without articular thrust (Cleland et al., 2007b). It seems that positive results persist in a medium e long term follow-up when SM is combined with different techniques, such as electro-thermal therapy (González-Iglesias et al., 2009b) and exercise-based interventions (Cleland et al., 2010).

The present study has been unable to indicate any major or clinical differences in pain perception between the TSM techniques. It could be argued that pain alleviation seems to occur after SM without the specific need of a concrete technique or segment to be treated. This issue, however, remains controversial. SM along with exercises seems to be more effective in the cervical than in the thoracic spine (Puentedura et al., 2011), and a successful result after SM has been linked with hypomobility at T1 (Saavedra-Hernández et al., 2011).

4.4. Changes in PPT measurements

Even though PPT augmented after intervention in both groups, the study results show that the toggle-recoil technique appears to have a slightly more favorable effect on increasing PPT than the dog technique. However, there were no statistical or clinical differences between-groups (Table 3). The observed changes did not surpass the established threshold to report a MDC in NP patients (Walton et al., 2011).

In line with the present findings, mechanosensitivity has been purported to improve significantly after SM in NP (Parkin-Smith and Penter, 1998; Suter and McMorland, 2002; Mansilla-Ferragut et al., 2009; de Camargo et al., 2011). Contradictory results have also been reported when comparing a rotary and a lateral break manipulation. No significant changes were observed in mechanical sensitivity after thrust manipulation although PPT values increased in both groups (van Schalkwyk and Parkin-Smith, 2000). However, SM was delivered in all previous studies to the cervical spine, except in one trial in which cervical and TSM were combined (Parkin-Smith and Penter, 1998).

As mentioned by Coronado et al. (2012), SM may have a greater impact on improving PPT levels than active treatments, such as exercise and patient education. It seems to achieve a hypoalgesic effect locally and also in different innervated-related areas (de Camargo et al., 2011), as shown in this study. These changes have been explained based on a spinal cord mediated mechanism (Bialosky et al., 2009b) and a chain of neuro-physiological responses related to the central and peripheral nervous systems (Bialosky et al., 2009a).

4.5. Cervical mobility

The observed improvement in cervical ROM followed the pattern described in the literature after TSM in patients with NP (Cleland et al., 2005; Fernández de las Peñas et al., 2007; Krauss et al., 2008). The findings in the TRG surpassed the MDC previously reported for extension (5.1), left rotation (4.9) and left lateral flexion (3.6) (Audette et al., 2010) (Table 2).

When SM has been performed during several sessions, along with other treatments, and with a longer follow-up period, (González-Iglesias et al., 2009a,b; Cleland et al., 2010; Lau et al., 2011), the positive results in cervical mobility have been maintained. Nevertheless, the TSM technique and the manipulated thoracic segment differed among the studies. Likewise, cervical mobility was assessed with different tools, which makes comparison between trials quite difficult.

4.6. Comparison between SM techniques

No major or clinical differences were found between the TSM techniques on the outcome variables. There were only slight differences in their effect on cervical ROM because the TRG increased mobility and exceed the MDC in extension, left rotation and left lateral flexion. The results appear to reinforce the understanding of SM as a non-specific technique acting on the pain modulating system, even though the mechanisms still remain elusive (Coronado et al., 2012).

4.7. Adverse events reported in the study

No ‘major’, ‘moderate’, and/or ‘mild’ adverse events, (Carnes et al., 2010) were reported by the subjects throughout the research period.

4.8. Study limitations

Participants had chronic NP and a low baseline self-perceived pain. Therefore, results should be compared with subjects suffering from acute NP. Furthermore, no control group was included and no previous screening for vertebral dysfunctions was made. In addition, results have only been evaluated in the short term. Four subjects who did not achieve cavitation were excluded. Although there is evidence to support that hypoalgesia is related to SM regardless of audible cavitations (Sillevis and Cleland, 2011), there is controversy concerning this issue. Neuro-physiological effects after SM may be higher when associated with an audible pop (Bialosky et al., 2010), and thrust manipulation is usually repeated if a popping sound is not heard on the first attempt (Dunning et al., 2013).

No assessment of the force applied in each technique has been made, so the possible differences in dosage remain a matter for future studies. Interventionist blinding was not possible, which may represent a potential of bias from the clinician. There is confusion surrounding the terms single and double blind (Miller and Stewart, 2011). The quality of a randomized trial is also based on aspects that were controlled such as outcome assessor and participant blinding, along with interventionist training (Chess and Gagnier, 2013).

Conclusions

After a single intervention, no major or clinical differences were observed between the toggle recoil and the dog techniques for neck pain, mobility and mechanical sensitivity in subjects with NSNP.

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Fig. 1. Flow diagram.

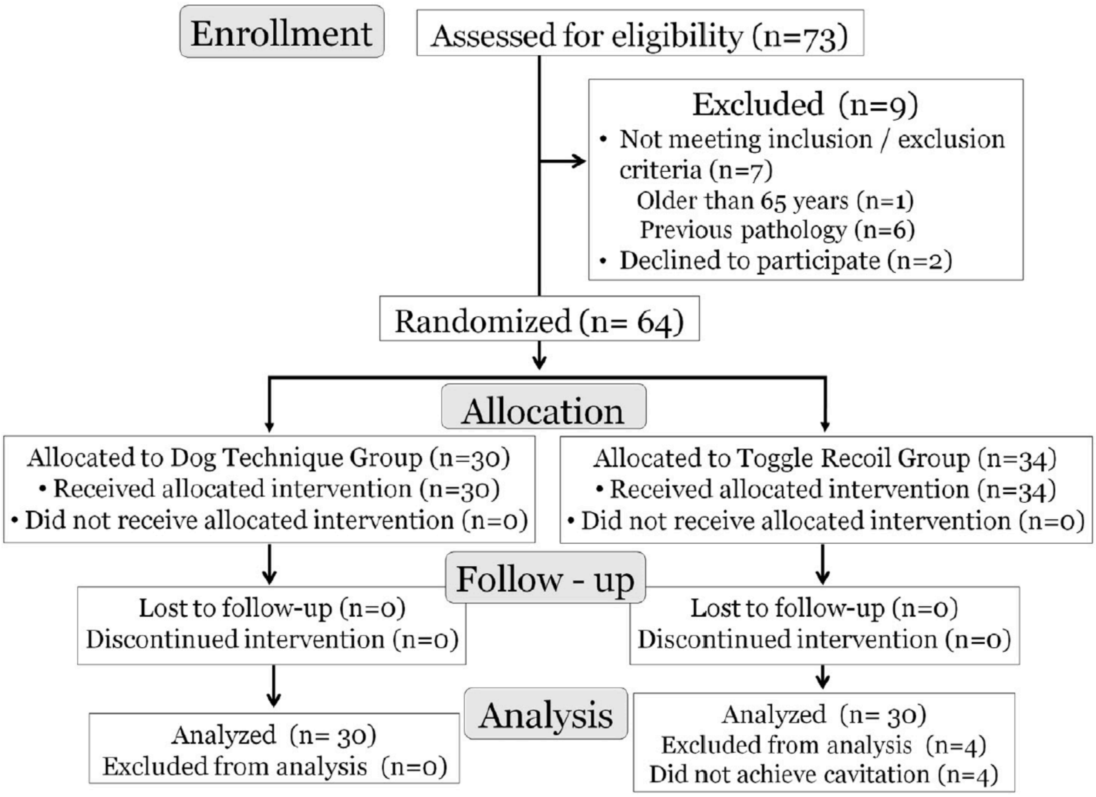
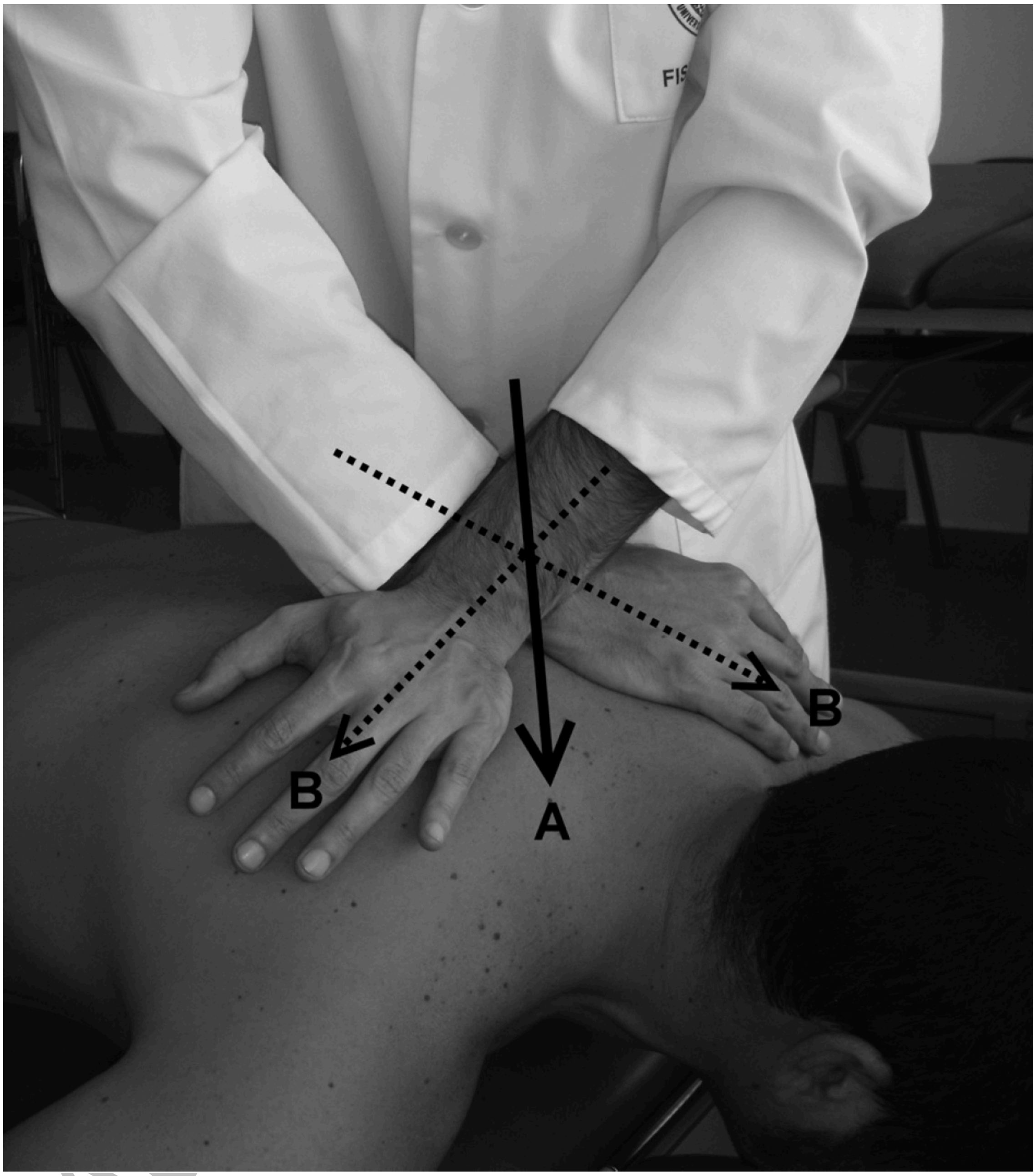


Fig. 2. Dog technique.

A - Thrust impulse direction.

Fig. 3. Toggle - recoil technique.



A - Thrust impulse direction. B – Pretension adjustment.

Table 1. Physical and clinical baseline characteristics of the participants.

	Group (n = 30)		p-value*
	Dog technique	Toggle recoil	
Age (years)	37.53 ± 9.39	37.73 ± 11.25	0.943
Sex (n, %)			
Male	10 (33.3%)	7 (23.3%)	0.396[a]
Female	20 (66.7%)	23 (76.7%)	
Handedness (n, %)			
Right-handed	28 (93.3%)	28 (93.3%)	1.00[a]
Left-handed	2 (6.7%)	2 (6.7%)	
Weight (kg)	66.96 ± 12.03	66.16 ± 14.12	0.814
Height (m)	1.66 ± 0.07	1.66 ± 0.08	0.976
VAS (mm)	24.9 ± 16.4	23.8 ± 17.0	0.805
ROM F (°)	51.50 ± 11.27	50.36 ± 10.70	0.691
ROM E	61.70 ± 15.83	65.96 ± 12.56	0.252
ROM RLF	35.66 ± 11.27	37.13 ± 8.93	0.579
ROM LLF	38.96 ± 7.64	42.10 ± 8.55	0.140
ROM RR	55.00 ± 14.60	64.93 ± 13.96	0.009
ROM LR	59.46 ± 14.75	65.73 ± 15.34	0.112
PPT C4 (kg/cm^2)	2.01 ± 0.62	1.96 ± 0.80	0.812
PPT T4	3.70 ± 1.42	3.35 ± 1.24	0.322
PPT RUT	3.06 ± 1.22	2.79 ± 1.19	0.470
PPT LUT	3.46 ± 1.44	3.18 ± 1.3	0.443

Data are reported as mean ± standard deviation or as frequencies (%). Note: VAS. visual analogue scale; ROM. range of motion; F. flexion; E. extension; RLF. right lateral flexion; LLF. left lateral flexion; RR. right rotation; LR. left rotation; PPT. pressure pain threshold; C4. fourth cervical vertebra; T4. fourth thoracic vertebra; RUT. right upper trapezius; LUT. left upper trapezius. *p-value. statistical significance of the between-group differences using independent t-test.

[a] As determined by chi square test.

Table 2. Intra-group differences of the score changes after intervention (post-intervention - pre-intervention).

Outcome measures	Group	Score changes immediate post- – pre-intervention	Score changes 20 min post (short term) – pre-intervention	*p*-value
VAS (mm)	DTG	–12.6 (–19.8/–5.5)	–15.8 (–22.4/–9.2)	<0.001
	TRG	–14.7 (–20.2/–9.2)	–17.2 (–22.1/–12.2)	<0.001
ROM F (°)	DTG	2.90 (5.83/–0.03)	2.43 (5.13/–0.26)	0.053*
	TRG	6.16 (8.39/3.93)	5.16 (7.68/2.64)	<0.001
ROM *E*	DTG	3.16 (5.42/0.90)	3.23 (5.70/0.76)	0.010
	TRG	7.76 (10.38/5.14)	5.76 (9.23/2.30)	<0.001
ROM RLF	DTG	0.60 (3.15/–1.95)	0.20 (2.13/–2.53)	0.740*
	TRG	1.46 (3.46/–0.53)	4.06 (5.79/2.34)	<0.001
ROM LLF	DTG	1.10 (2.67/–0.47)	1.10 (2.70/–0.50)	0.288*
	TRG	2.20 (4.19/0.20)	3.23 (5.31/1.14)	0.003
ROM RR	DTG	3.80 (6.63/0.96)	3.40 (5.67/1.12)	0.004
	TRG	5.40 (8.29/2.50)	4.86 (8.05/1.68)	0.001
ROM LR	DTG	3.26 (5.68/0.84)	2.10 (3.70/0.49)	0.009
	TRG	7.86 (10.67/5.05)	7.36 (9.89/4.84)	<0.001
PPT C4	DTG	0.21 (0.39/0.03)	0.25 (0.47/0.03)	0.015
(kg/cm^2)	TRG	0.21 (0.33/0.09)	0.30 (0.45/0.14)	0.001
PPT T4	DTG	0.40 (0.62/0.18)	0.47 (0.76/0.19)	0.001
	TRG	0.37 (0.62/0.12)	0.70 (0.99/0.40)	<0.001
PPT RUT	DTG	0.20 (0.45/–0.03)	0.34 (0.70/–0.01)	0.062*
	TRG	0.40 (0.60/0.21)	0.40 (0.59/0.20)	0.001
PPT LUT	DTG	0.24 (0.47/0.05)	0.29 (0.57/0.01)	0.037
	TRG	0.41 (0.60/0.22)	0.45 (0.66/0.25)	<0.001

Data are reported as the difference between final and baseline values, expressed as mean (95% confidence interval). Note: DTG. dog-technique group; TRG. toggle-recoil group; VAS. visual analogue scale; ROM. range of motion; F. flexion; E. extension; RLF. right lateral flexion; LLF. left lateral flexion; RR. right rotation; LR. left rotation; PPT. pressure pain threshold; C4. fourth cervical vertebra; T4. fourth thoracic vertebra; RUT. right upper trapezius; LUT. left upper trapezius. *Non-statistically significant intra-group differences ($p > 0.05$).

Table 3. Between-groups comparison of the score changes after intervention (changes in the TRG minus changes in the DTG).

Outcome measures	Score changes immediately after intervention	p	Score changes in the short term after intervention	p
VAS (mm)	−2.0 (6.8/−10.8)	0.648	−1.3 (6.7/−9.4)	0.738
ROM F (°)	3.26 (6.87/−0.34)	0.075	2.73 (6.34/−0.88)	0.136
ROM E	4.60 (7.98/1.21)	0.009	2.53 (6.69/−1.63)	0.228
ROM RLF	0.86 (4.03/−2.30)	0.587	4.26 (7.10/1.42)	0.004
ROM LLF	1.10 (3.58/−1.38)	0.379	2.13 (4.70/−0.42)	0.102
ROM RR	1.60 (5.56/−2.36)	0.422	1.46 (5.29/−2.36)	0.446
ROM LR	4.60 (8.22/0.97)	0.014	5.26 (8.19/2.33)	0.001
PPT C4 (kg/cm^2)	0.00 (0.21/−0.21)	0.976	0.04 (0.30/−0.22)	0.751
PPT T4	−0.03 (0.29/−0.35)	0.855	0.22 (0.62/−0.17)	0.271
PPT RUT	0.20 (0.50/−0.10)	0.268	0.05 (0.45/−0.34)	0.888
PPT LUT	0.17 (0.47/−0.12)	0.252	0.16 (0.50/−0.17)	0.347

Data are reported as mean (95% confidence interval). Results were in favor to the TRG. Note: TRG. toggle-recoil group; DTG. dog-technique group; VAS. visual analogue scale; ROM. range of motion; F. flexion; E. extension; RLF. right lateral flexion; LSB. left lateral flexion; RR. right rotation; LR. left rotation; PPT. pressure pain threshold; C4. fourth cervical vertebra; T4. fourth thoracic vertebra; RUT. right upper trapezius; LUT. left upper trapezius.