



## Original article

## Is one better than another?: A randomized clinical trial of manual therapy for patients with chronic neck pain



Honorio Izquierdo Pérez<sup>a</sup>, Jose Luis Alonso Perez<sup>a,b,f</sup>, Alfonso Gil Martinez<sup>c,d</sup>, Roy La Touche<sup>c,d</sup>, Sergio Lerma-Lara<sup>d,e</sup>, Noelia Commeaux Gonzalez<sup>b</sup>, Hector Arribas Perez<sup>f</sup>, Mark D. Bishop<sup>g</sup>, Josue Fernández-Carnero<sup>b,h,\*</sup>

<sup>a</sup> Department of Physiotherapy, Universidad Europea de Madrid, Villaviciosa de Odon, Madrid, Spain

<sup>b</sup> Research Group in Musculoskeletal Pain and Motor Control, Universidad Europea de Madrid, Villaviciosa de Odon, Spain

<sup>c</sup> Hospital La Paz Institute for Health Research, IdiPAZ, Madrid, Spain

<sup>d</sup> Faculty of Health Science, Department of Physiotherapy, The Center for Advanced Studies University La Salle, Autonoma University of Madrid, Aravaca, Madrid, Spain

<sup>e</sup> Movement Analysis Laboratory, University Hospital Niño Jesus, Madrid, Spain

<sup>f</sup> Department of Physical Therapy, University Hospital del Henares, Coslada, Madrid, Spain

<sup>g</sup> University of Florida, Department of Physical Therapy, United States

<sup>h</sup> Department of Physical Therapy, Occupational Therapy, Rehabilitation and Physical Medicine, Universidad Rey Juan Carlos, Alcorcón, Madrid, Spain

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## ABSTRACT

Our purpose was to compare the effectiveness of three manual therapy techniques: high velocity, low amplitude (HVLA), mobilization (Mob) and sustained natural apophyseal glide (SNAG) in patients with chronic neck pain (CNP). The randomized controlled trial included patients with mechanically reproducible CNP, who were randomized to the treatment group. Outcome measures were the Visual Analogue scale (VAS), Neck Disability Index (NDI), Global Rating of Change (GROC) and Cervical Range of Motion (CROM). Two-way repeated measures analysis of variance compared outcomes at baseline, at the end of treatment and **1, 2 and 3 months** after treatment. A total of **51 subjects** completed the trial. No significant differences were found between HVLA, Mob and SNAG at the end of treatment and during the follow-up in any of the analysed outcomes. There were no differences in satisfaction for all techniques. The results lead to the conclusion that **there is no long-term difference** between the application of HVLA, Mob and SNAG in pain, disability and cervical range of motion for patients with CNP.

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## 1. Introduction

The incidence of neck pain is increasing at a greater rate than other spine pain problems (Picavet and Schouten, 2003), incurring growing personal, social and health costs (Hoving et al., 2004). The expenditure on patients with neck pain is increasing at a faster rate than for other, more prevalent health problems (Martin et al., 2008). Most individuals will suffer neck pain at some time during the course of their lives (Carroll et al., 2008). Recently, a study reported that the 1-year prevalence in Spain was 19.5% (Fernandez-

delas-Penas et al., 2011) and a third of these cases will transition into a chronic state (Cote et al., 2004).

The zygapophyseal joints are a source of neck pain (Bogduk and Aprill, 1993; Bogduk, 2011). Cervical mobilization and manipulation applied to these joints have demonstrable effects on the autonomic nervous system, the sensory system, neck range of motion and disability levels (Martinez-Segura et al., 2006; Schmid et al., 2008; Bialosky et al., 2009; Dunning and Rushton, 2009). Similarly, the sustained natural apophyseal glide (SNAG) technique produces sympathoexcitatory effects (Moulson and Watson, 2006) and increases in range of motion (McNair et al., 2007). SNAGs are recommended as a suitable manual technique for treatment of patients with neck pain (Mulligan, 1999; Hearn and Rivett, 2002). Nevertheless, no studies have compared the effects of this technique with those of other manual therapies more commonly used on patients with neck pain, which was one factor which prompted this study.

\* Corresponding author. Facultad de Ciencias de la Salud, Departamento de Fisioterapia, Terapia Ocupacional, Medicina Física y Rehabilitación, Universidad Rey Juan Carlos, Avenida de Atenas s/n, 28922 Alcorcón, Madrid, Spain. Tel.: +34 91 488 89 59; fax: +34 91 488 89 57.

E-mail addresses: [josue.fernandez@urjc.es](mailto:josue.fernandez@urjc.es), [josuefernandezcarnero@gmail.com](mailto:josuefernandezcarnero@gmail.com) (J. Fernández-Carnero).

There are potential adverse effects related to cervical manipulation (Leon-Sanchez et al., 2007), especially the possibility of neurovascular injuries (Thomas et al., 2011, 2012a, 2012b). For this reason, recommendations have been made to avoid manual therapy (MT) at terminal ranges of motion (Childs et al., 2005). Cautions have been given against the use of cervical high-velocity low-amplitude (HVLA) techniques, especially in specific subgroups of the population (Kerry and Taylor, 2009). Before HVLA is avoided due to these risks, there is a need to determine if HVLA has any superior effects to low velocity techniques such as SNAGs or other mobilization techniques.

A study was undertaken to better understand the clinical effects of the SNAG technique and also where there were any differences in its effects compared to other common manual therapy techniques in patients with neck pain. Saavedra-Hernandez et al. (2012) reported that there is a correlation between cervical range of motion and pain. The SNAG technique involves a series of repeated movements aimed at gaining range and reducing pain (Hearn and Rivett, 2002). Thus we hypothesized that SNAGs would have better effects than mobilization and HVLA techniques. To test this hypothesis, this study compared the immediate and short-term effectiveness of HVLA, Mob and the SNAG techniques on measures of pain, disability, mobility and the global rating scale for patients with chronic neck pain.

## 2. Methodology

### 2.1. Design

This study was a parallel-group double blind randomized clinical trial (see <http://www.clinicaltrials.gov>. Identifier: NCT01792895). The randomization schedule was prepared using Graphpad (Graphpad Software, Inc CA 92037 USA) before enrolment and treatment group was concealed in opaque envelopes. The assessor undertaking baseline measures was blind to the subject's group and patients were also blinded/uninformed to the type of treatment technique received. This study was approved by the Ethics Committee Board. All patients completed the informed consent process.

### 2.2. Subject selection

Sixty-nine patients with mechanical neck pain aged between 20 and 65 years were assessed for eligibility by a primary care physician. The study was conducted in the Valleaguado Primary Health Care Centre in Coslada, Spain over 10 months from October 2011 to June 2012. Once a patient was deemed eligible and accepted into the study, an envelope was selected and the patient was randomized to one of three MT groups. Nineteen were randomized to the HVLA group, 21 to the Mob group and 21 to the SNAG group. The patients were instructed not to discuss the MT procedure received with the examiner.

Inclusion criteria were pain perceived anywhere in the posterior region of the cervical spine, from the superior nuchal line to the first thoracic spinous process (Merskey and Bogduk, 1994) of more than 12 weeks duration and without radicular symptoms radiating to the head, trunk and/or the upper limbs. Patients were not considered if they reported any of the following conditions: pregnancy, neck pain associated with whiplash injuries, medical red flag history (tumour, fracture, metabolic diseases, rheumatoid arthritis, osteoporosis, resting blood pressure greater than 140/90 mmHg), neck pain with cervical radiculopathy, neck pain associated with externalized cervical disc herniation, fibromyalgia syndrome, previous neck surgery, neck pain accompanied by vertigo caused by vertebrobasilar insufficiency or accompanied by non-cervicogenic

headaches. People were also not considered if they had received physical therapy in the previous 6 months, had pending legal action (compensation for injury, labour), psychiatric disorders or other problems that could contraindicate the use of techniques in this study.

### 2.3. Interventions

All groups were assessed by a physiotherapist with more than 10 years of clinical experience. A standardized musculoskeletal examination of the cervical spine was performed to identify the vertebral level to target with the intervention; that is, the level found to be hypomobile and painful in the manner that matched the patients' primary complaint. Each patient received a total of 4 treatment sessions over 2 weeks. Four sessions were chosen, taking as a reference a similar study by Leaver et al. (2010).

#### 2.3.1. HVLA Group

The patient lay supine with the cervical spine in a neutral position. The therapist applied contact over the posterolateral aspect of the zygapophyseal joint of the hypomobile vertebra. The therapist performed the technique taking into account the most limited movement: lateral flexion or rotation. A maximum of 2 thrusts were performed on each subject regardless of audible cavitation (Flynn et al., 2003; Cleland et al., 2007).

#### 2.3.2. Mob group

The patient lay prone and the therapist stood at the head of the patient. His thumbs were placed in opposition at the level of the facet of the hypomobile cervical vertebra and a unilateral posterio-anterior (PA) oscillatory pressure was applied (Sterling et al., 2001). This oscillatory mobilization was performed at a frequency of 2 Hz (with metronome control/steps) for 2 min and repeated 3 times. The rest time between each mobilization was 1 min.

#### 2.3.3. SNAG Group

The patient was in a sitting position. The therapist located the hypomobile and painful level and placed his thumbs on the transverse process of that level. Then, the subject performed the painful motion actively while the therapist guided that vertebra during the movement and resisted it when returning to neutral. The force was applied parallel to the plane of the joint (Exelby, 2002), and the procedure was performed in 3 sets of 10 repetitions.

### 2.4. Outcome measures

#### 2.4.1. Primary outcomes

**2.4.1.1. Pain intensity.** A Visual Analogue Scale (VAS) was used to evaluate the intensity of the recent pain perceived by the patient (Huskisson, 1974). This scale has been documented in previous studies as a reliable and valid measure of pain intensity (Jensen et al., 1999; Katz and Melzack, 1999) and it is sensitive to clinical changes in pain (Guzman et al., 2008). The patient places a vertical mark on a 10 cm horizontal line anchored at one end with 0 (no pain) and at the other end with 10 (maximum pain). A change of 1.1–1.2 cm indicates a minimal improvement, which is clinically significant (Emshoff et al., 2011).

#### 2.4.2. Secondary outcomes

**2.4.2.1. Disability of the neck.** The Neck Disability Index (NDI) is an assessment tool used to record perceived disability in patients with neck pain (Vernon and Mior, 1991). The NDI is a self-administered questionnaire with 10 sections: 7 relate to activities of daily living, 2 relate to pain and 1 to concentration. Each of the sections is scored from 0 to 5, and the total score is expressed as a percentage

relative to the maximum possible. The validated Spanish version was used in this study (Andrade Ortega et al., 2010). This scale offers high levels of validity and reliability (Cronbach's alpha score was 0.89); it is stable against different cultural levels and is consistent and reliable (Wheeler et al., 1999). The minimum detectable change is 5 points out of 50, and it is recommended that 7 points is the minimum clinically important difference (MacDermid et al., 2009).

**2.4.2.2. Active cervical range of motion movement (ACROM).** The ACROM is an instrument that assesses the active range of motion of the cervical spine and has been used in numerous studies to evaluate the results in manual therapy (Martinez-Segura et al., 2006; Krauss et al., 2008). Furthermore, it has proven to be a reliable measure (Zachman et al., 1989; Audette et al., 2010), providing intra-rater reliability ranging from 0.7 to 0.9 and inter-rater reliability ranging from 0.8 to 0.87. The minimum detectable changes are 5.1° for extension, 6.5° for flexion, 4.9° for left rotation, 6.1° for right rotation, 4.2 for left lateral flexion and 3.6° for right lateral flexion (Fletcher and Bandy, 2008; Audette et al., 2010). The patient sat in a chair and the goniometer was placed over his or her head. They were asked to perform active neck movements to the point of the beginning of pain symptoms or, otherwise, to the fullest extent of mobility. Each movement was recorded three times and the average value calculated.

**2.4.2.3. Global perceived improvement.** The Global Rating of Change Scale (GROC) is commonly used in clinical research, particularly in patients with neck pain (Koes et al., 1992a, b; Jull et al., 2002). It is designed to quantify the improvement or deterioration over time and it allows the patient to choose the aspects of life that are considered important (Kamper et al., 2009). In this study we used the GROC described by Jaeschke et al. (Jaeschke et al., 1989) that ranges from –7 (much worse) to +7 (much better) with 0 being the midpoint (equal).

## 2.5. Follow-up

The follow-up consisted of five evaluations carried out by a physiotherapist blind to treatment assignment. The evaluations were performed before treatment, immediately after treatment, and one, two and three months after treatment. In order to prevent drop outs, all patients were phoned about the appointment by the Primary Care Research Unit.

## 2.6. Sample size

The sample size and power calculations were performed using software from the Massachusetts General Hospital's (MGH) Biostatistics Center (Boston, MA). The Visual Analogue scale was chosen as the primary measure in this study. Calculations were based on detecting a 0.86 cm difference in the Visual Analogue Scale (VAS) from rest to immediately and 3 months after treatment based on a previous study's score of <4 cm with a pain onset more than 12 weeks (Emshoff et al., 2011), assuming a standard deviation of 0.75 cm, 2-tailed tests and an alpha level of 0.05. This generated a sample size of 13 patients per group (39 patients) for the study to have 80% power to identify an effect. Allowing for a dropout rate of 20%, we planned to recruit at least 47 patients. This sample size calculation method has been used in previous studies (Dunning et al., 2012).

## 2.7. Data analysis

Data were analysed using the SPSS, v19 (SPSS, Chicago, IL). All data passed a test of normality using the Kolmogorov–Smirnov test

( $P > 0.05$ ) except for GROC. The Kruskal–Wallis test was used to analyse the ordinal variables. Means and standard deviations were calculated for each variable. Intention-to-treat (last value carried forward) was used to account for missing data. All patients had an appointment set for each session. The day before, they were called to remind them of the appointment. Even so, a few did not attend, and they were called again to set a new appointment. In the end, there were 2 drop outs in the HVLA group, 3 in the Mob group and 5 in the SNAG group. The baseline and demographic data at pre-treatment were compared between groups using a one-way analysis of variance (ANOVA). A 2-way repeated measures ANOVA was performed to evaluate the effect on all the variables, of the factors of intervention (HVLA, Mob, SNAG) and time (pretreatment, immediately after, and 1, 2 and 3 months). Demographic variables that differed between groups and were related to the outcomes were included in the models as covariates. Tests of within-patients post hoc simple effects (i.e. changes in time for all variables for each group separately) were performed with Bonferroni corrections. In all statistical comparisons,  $P < 0.05$  was used as the criterion for statistical significance.

## 3. Results

### 3.1. Participants

The patients were recruited from September 2011 to May 2012. Sixty-one patients with non-specific neck pain were eligible for the study. Fifty-one patients completed all assessments (Fig. 1). The primary reason given for dropping out was that the patients reported that they were very much improved and they did not want to continue with the study. There were no adverse events reported with any intervention. Data of all variables had a normal distribution ( $P > 0.05$ ). Baseline and patients' characteristics for all groups are presented in Table 1. No statistical differences were found in the baseline variables between the groups; 83.6% were women and the average age of the population was 36.5 years ( $\pm 9.4$ ). The mean duration of symptoms was in 90.1 ( $\pm 106.4$ ) weeks and there were no differences in the duration of pain ( $F = 0.61$ ,  $P = 0.54$ ). The statistical power for detecting a medium effect size of 0.25 with this sample size was 0.96 (3  $\times$  5 repeated measures ANOVA, within-between interactions).

### 3.2. Interventions

#### 3.2.1. Pain measures – Visual Analogue Scale at rest (VAS-rest)

For the VAS-rest, the ANOVA revealed a significant effect for time ( $F = 10.38$ ,  $P < 0.0001$ , Partial  $\eta^2 = 0.54$ ) but not for group/time interaction ( $F = 0.12$ ,  $P < 0.83$ , Partial  $\eta^2 = 0.06$ ). In general, the VAS-rest decreased for all groups. Details of the VAS-rest in all groups during the study are shown in Table 2.

#### 3.2.2. Disability outcomes

No differences were found in the reduction of disability between groups from pre-treatment to the third month. The ANOVA revealed a significant effect for time ( $F = 33.56$ ,  $P < 0.0001$ , Partial  $\eta^2 = 0.37$ ) but not for group/time interaction ( $F = 1.03$ ,  $P = 0.41$ , Partial  $\eta^2 = 0.03$ ). Details of the NDI are showed in Table 2.

#### 3.2.3. Active cervical range of movement (ACROM)

The ANOVA revealed a significant effect for time (flexion  $F = 27.99$ ,  $P < 0.0001$ , Partial  $\eta^2 = 0.31$ ; extension  $F = 26.18$ ,  $P < 0.0001$ , Partial  $\eta^2 = 0.31$ ; right rotation  $F = 17.84$ ,  $P < 0.0001$ , Partial  $\eta^2 = 0.23$ ; left rotation  $F = 22.14$ ,  $P < 0.0001$ , Partial  $\eta^2 = 0.27$ ; right lateral flexion  $F = 18.81$ ,  $P < 0.0001$ , Partial  $\eta^2 = 0.24$ ; left lateral flexion  $F = 16.13$ ,  $P < 0.0001$ , Partial

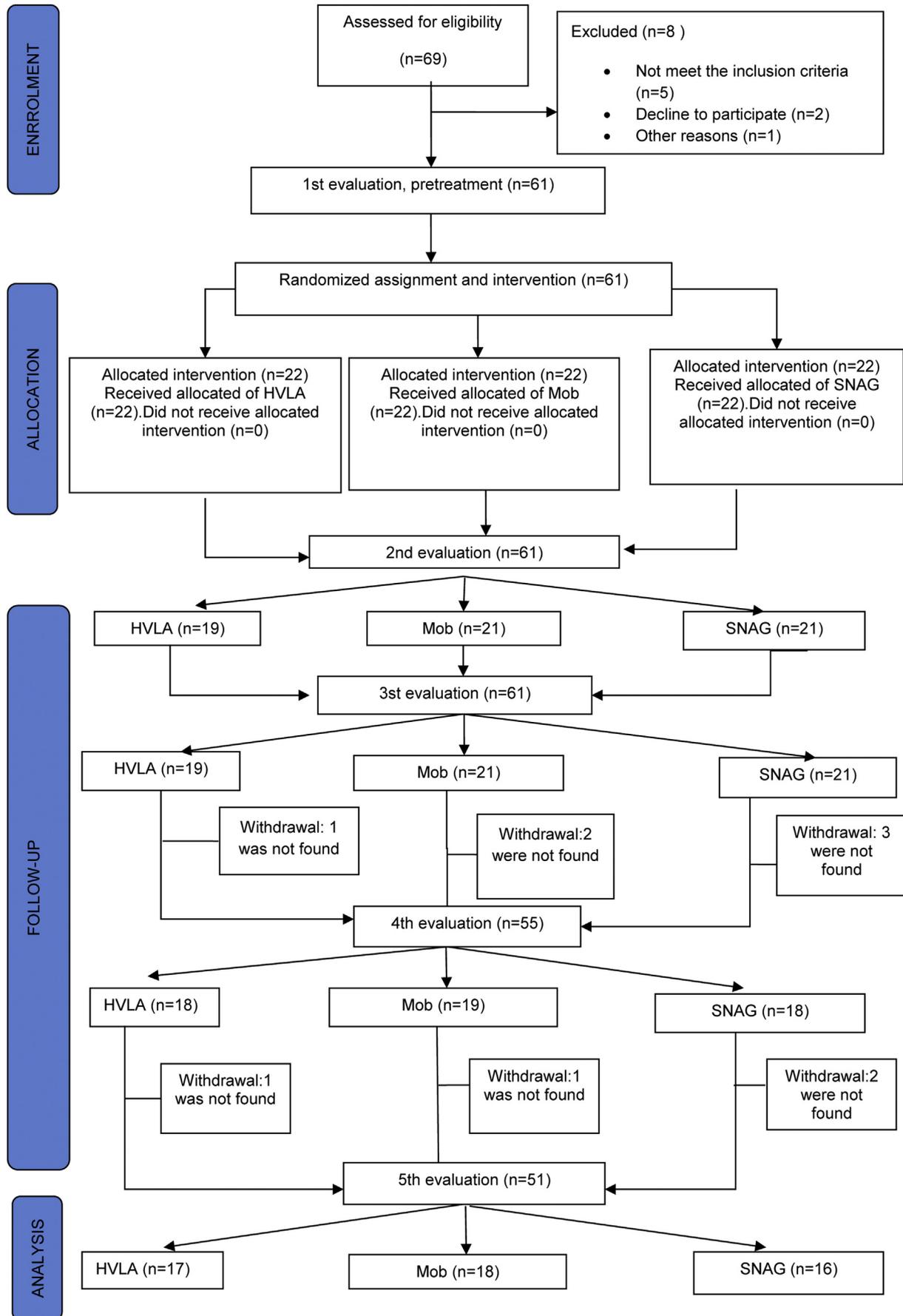


Fig. 1. Flow diagram of the clinical trial.

**Table 1**Demographic characteristics and baseline measures presented by group. all data are presented as mean  $\pm$  SD (95%IC) unless otherwise indicated.

Characteristic	HVLA group	Mob group	SNAG group	P
	N = (19)	N = (21)	N = (21)	
Age years	36.2 $\pm$ 8.9 (31.8–40.5)	35.6 $\pm$ 10.3 (30.9–40.3)	37.8 $\pm$ 9.1 (33.6–42.0)	0.7
Height (metres)	1.69 $\pm$ 0.08	1.70 $\pm$ 0.08	1.73 $\pm$ 0.07	0.2
Sex (M/F (Female %))	10/9 (53%)	12/9 (57%)	13/8 (62%)	0.7
Chronicity (months)	74.4 $\pm$ 102.3 (25.0–125.0)	84.0 $\pm$ 102.2 (37.3–130.4)	110 $\pm$ 115.5 (57.7–163.0)	0.5

**Table 2**

Between-group differences for changes from baseline in patients satisfaction, disability and pain intensity.

Measurements	Follow up periods	HVLA group	Mob group	SNAG group
		Mean $\pm$ SD (95%IC)	Mean $\pm$ SD (95%IC)	Mean $\pm$ SD (95%IC)
GROC	Pre	–	–	–
	Post	4.0 $\pm$ 2.1 (3.1–4.9)	3.8 $\pm$ 1.8 (3.0–4.6)	3.8 $\pm$ 1.7 (3.0–4.6)
	Follow up 1	2.8 $\pm$ 2.6 (1.6–4.0)	3.3 $\pm$ 2.3 (2.2–4.5)	4.0 $\pm$ 2.7 (2.9–5.2)
	Follow up 2	3.3 $\pm$ 3.0 (2.0–4.6)	3.2 $\pm$ 2.4 (2.0–4.4)	4.2 $\pm$ 2.8 (3.03–5.44)
	Follow up 3	3.3 $\pm$ 2.9 (2.0–4.5)	3.3 $\pm$ 2.1 (2.1–4.5)	4.2 $\pm$ 2.8 (3.0–5.3)
NDI	Pre	15.0 $\pm$ 5.5 (10.6–19.3)	16.5 $\pm$ 7.8 (12.5–20.5)	17.9 $\pm$ 7.3 (14.1–21.8)
	Post	9.2 $\pm$ 5.5 (4.0–14.5)	10.7 $\pm$ 9.4 (5.9–15.5)	13.1 $\pm$ 9.5 (8.5–17.8)
	Follow up 1	10.4 $\pm$ 5.9 (5.3–15.4)	10.7 $\pm$ 9.0 (6.0–15.4)	11.1 $\pm$ 9.2 (6.6–15.6)
	Follow up 2	9.4 $\pm$ 8.1 (3.63–15.1)	11.3 $\pm$ 9.6 (6.0–16.6)	10.8 $\pm$ 9.9 (5.8–15.9)
	Follow up 3	12.1 $\pm$ 8.1 (6.8–17.3)	11.1 $\pm$ 8.7 (6.4–16.1)	11.1 $\pm$ 8.8 (6.5–15.8)
VAS rest	Pre	3.0 $\pm$ 1.9 (2.0–3.9)	2.7 $\pm$ 1.9 (1.9–3.6)	2.9 $\pm$ 2.2 (1.9–3.8)
	Post	1.0 $\pm$ 1.4 (0.2–1.9)	0.8 $\pm$ 1.6 (0.0–1.6)	1.5 $\pm$ 2.3 (0.7–2.3)
	Follow up 1	0.9 $\pm$ 1.3 (0.3–1.6)	0.6 $\pm$ 1.1 (–0.0 to 1.2)	1.1 $\pm$ 1.9 (0.4–1.8)
	Follow up 2	0.8 $\pm$ 1.4 (0.1–1.5)	0.6 $\pm$ 1.0 (–0.0 to 1.3)	1.2 $\pm$ 2.0 (0.6–1.9)
	Follow up 3	1.0 $\pm$ 1.7 (0.3–1.8)	0.6 $\pm$ 1.1 (–0.1 to 1.3)	1.2 $\pm$ 1.9 (0.5–1.9)

eta = 0.21). No group/time interactions were identified for any movement ( $P > 0.05$ ) except extension (Extension  $F = 1.95$ ,  $P = 0.02$ , Partial eta = 0.06). The Bonferroni correction comparison revealed that the HVLA group had greater increases in extension ( $P < 0.01$ ) than the Mob and SNAG ( $P > 0.05$ ) groups at all the follow-up months. Mob increased extension movement immediately ( $P < 0.01$ ) but not during the follow-up ( $P > 0.05$ ). SNAG increased only during the one month follow-up ( $P < 0.01$ ). Details of ACROM in all groups during the study are shown in Table 3.

### 3.2.4. Global rating of change

The Kruskal–Wallis test revealed no significant effects between groups ( $P > 0.05$ ) for GROC (Table 2).

**Table 3**

Between-group differences for changes from baseline in patients range of motion score.

Range of motion	Follow up periods	HVLA group	Mob group	SNAG group
		Mean $\pm$ SD (95%IC)	Mean $\pm$ SD (95%IC)	Mean $\pm$ SD (95%IC)
FLEX	Pre	37.7 $\pm$ 11.6 (31.4–43.9)	45.1 $\pm$ 15.4 (39.2–51.1)	40.0 $\pm$ 13.3 (34.1–45.9)
	Post	50.4 $\pm$ 10.0 (44.8–56.0)	55.7 $\pm$ 12.8 (50.4–61.0)	48.3 $\pm$ 13.2 (43.0–53.7)
	Follow up 1	49.2 $\pm$ 11.1 (43.2–55.3)	54.9 $\pm$ 13.9 (49.2–60.6)	52.4 $\pm$ 13.9 (46.7–58.1)
	Follow up 2	52.3 $\pm$ 15.5 (45.4–59.2)	54.6 $\pm$ 13.1 (48.0–61.1)	51.2 $\pm$ 16.1 (44.6–57.7)
	Follow up 3	50.9 $\pm$ 13.7 (44.4–57.3)	55.1 $\pm$ 14.1 (48.9–61.2)	52.6 $\pm$ 14.1 (46.5–58.8)
EXT	Pre	43.6 $\pm$ 21.9 (36.3–50.8)	49.6 $\pm$ 13.8 (42.6–56.5)	44.4 $\pm$ 10.1 (37.4–51.3)
	Post	63.3 $\pm$ 14.9 (57.2–69.4)	59.4 $\pm$ 13.4 (53.6–65.1)	57.7 $\pm$ 11.2 (51.9–63.5)
	Follow up 1	56.6 $\pm$ 16.9 (50.1–63.1)	53.8 $\pm$ 15.1 (47.6–59.9)	55.0 $\pm$ 9.7 (48.8–61.2)
	Follow up 2	54.3 $\pm$ 17.5 (47.3–61.2)	50.7 $\pm$ 16.6 (44.1–57.4)	53.9 $\pm$ 10.8 (47.3–60.6)
	Follow up 3	53.9 $\pm$ 18.4 (47.1–60.8)	51.6 $\pm$ 14.6 (45.1–58.1)	51.2 $\pm$ 11.2 (44.7–57.7)
ROT	Pre	112.8 $\pm$ 26.4 (93.3–132.3)	119.1 $\pm$ 32.9 (102.9–135.4)	111.9 $\pm$ 26.0 (96.3–127.6)
	Post	130.6 $\pm$ 30.3 (112.8–148.4)	131.3 $\pm$ 26.3 (116.5–146.2)	124.5 $\pm$ 23.4 (110.2–138.8)
	Follow up 1	124.4 $\pm$ 33.9 (105.1–143.8)	128.1 $\pm$ 27.4 (112.0–144.2)	126.1 $\pm$ 25.7 (110.6–141.6)
	Follow up 2	123.0 $\pm$ 36.1 (105.6–140.4)	126.7 $\pm$ 25.4 (112.3–141.2)	121.7 $\pm$ 16.7 (107.8–135.7)
	Follow up 3	120.5 $\pm$ 33.9 (102.9–138.1)	127.6 $\pm$ 23.7 (112.9–142.2)	121.4 $\pm$ 21.9 (107.3–135.5)
LAT FLEX	Pre	66.4 $\pm$ 19.4 (54.9–77.9)	68.7 $\pm$ 17.2 (59.1–78.2)	64.4 $\pm$ 14.9 (55.2–73.6)
	Post	78.0 $\pm$ 20.5 (65.1–90.9)	83.1 $\pm$ 20.2 (72.4–93.9)	76.8 $\pm$ 16.8 (66.4–87.1)
	Follow up 1	77.1 $\pm$ 21.5 (65.9–88.4)	77.1 $\pm$ 16.4 (67.7–86.4)	76.9 $\pm$ 12.7 (67.9–85.9)
	Follow up 2	70.4 $\pm$ 22.9 (57.4–83.4)	74.9 $\pm$ 22.7 (64.1–85.8)	76.5 $\pm$ 11.6 (66.0–86.9)
	Follow up 3	71.4 $\pm$ 25.1 (58.4–84.3)	75.3 $\pm$ 20.5 (64.5–86.0)	72.0 $\pm$ 12.3 (61.6–82.4)

## 4. Discussion

This study found no significant differences in outcomes between the techniques of SNAG, Mob and HVLA in the treatment of patients with mechanical pain. In all three groups, we found similar improvements in pain, disability, range of motion and patient perceived satisfaction.

To the authors' knowledge, this is the first study comparing the effectiveness of the SNAG technique against other techniques, and the first time that the three techniques have been evaluated jointly. Furthermore, our results are consistent with those obtained in previous studies of HVLA, Mob (Leaver et al., 2010) and the SNAG technique (McNair et al., 2007) in the treatment of neck pain. This allows us to have confidence in the results of this study.

Our results support and reinforce the fact that manual therapy has positive effects on neck pain. The magnitude of improvement in pain met the clinically important difference in all three manual therapy groups. The criterion reduction of 0.85 cm established by Emshoff et al. (2011) was met after the first session. There were no differences in the pain reduction between the three techniques. The short-term effects obtained in this study are similar to those reported by Saavedra-Hernández et al. (2012). Gross et al. (2010) compared Mob and HVLA in the management of chronic neck pain and their conclusions were the same namely; techniques of both mobilization and manipulation produced similar effects on pain, disability and satisfaction, results that agree with those obtained in the present study. The finding of pain reduction with the SNAG technique is also consistent with the findings of McNair et al. (2007), albeit that a second mobilization technique was added in that study. The results of this study support the use of the SNAG technique in the treatment of neck pain, and with Mob, it is effective as an alternative to HVLA, which would lessen the risk of vascular accident (Chakraverty et al., 2011).

Manual therapy is commonly used in the treatment of restricted range of motion, although the mechanical mechanisms of manual therapy remain uncertain. Neurophysiological effects of manual therapy previously have been identified including immediate hypoalgesia and an increase in pressure pain thresholds (Fernandez-de-las-Penas et al., 2007a; Fernandez-de-las-Penas et al., 2007b). Some studies (Ylinen et al., 2004; Saavedra-Hernandez et al., 2012) have reported a relationship between the cervical range of motion and pain. This situation led us to hypothesize that the SNAG technique would offer better results as it is mobilization with movement towards the restricted area. However, the hypothesis was rejected as we did not observe any significant differences between the three techniques. What we saw was increased range in all movements, both immediately post-treatment and at follow-ups. The range gained met the minimal detectable changes, which are 5.1° for extension and 6.5° for flexion (Audette et al., 2010), which were evident at the first month of follow-up and maintained for up to 12 weeks, except for the extension after Mob. This is consistent with previous studies. For example, Hakkinen et al. (2007) applied 8 sessions of Mob techniques combined with soft tissue techniques and followed patients up for 12 weeks. Patients increased their flexion and extension movements by 12° similar to our study (12.04° change from baseline to 12 weeks). Our results are also similar to those of Hoving et al. (2004) who combined manual therapy, soft tissue techniques and exercise, and gained an increase in range of motion in flexion and extension of 15° at 7 weeks after treatment.

Improvement occurred in disability (NDI) and improvements were similar between the three techniques both immediately and 12 weeks after treatment. However, none exceeded the minimum clinically important detectable difference change (7 points on the NDI) (Young et al., 2009). Only at 8 weeks did the SNAG technique show a clinically significant difference of 7.07 points. Saavedra-Hernández et al. (2012) obtained 6.9 and 10.6 point change in the NDI, a week after a single session of HVLA and a combination of HVLA techniques (cervical, thoracic and cervical spine), respectively. Hoving et al. (2004) found more than 7 points of change following 6 weeks of manual therapy treatment (Mob). Leaver et al. (2010) compared HVLA and Mob in patients with acute/sub-acute neck pain and reported a change of 9.6 and 7.9 in the NDI at 4 weeks after treatment and 9.3 to 10.8 after 12 weeks, which are greater than the changes found in our study. The review published by Gross et al. (2004) is at variance with our results for HVLA and Mob in the medium term. This may be because our patients had chronic neck pain and the application of more sessions may have improved results.

The three techniques resulted in a positive change in the global perception of change throughout the monitoring process, without statistical or clinically significant differences between the techniques. The changes are similar to those obtained by Leaver et al. (2010) but lesser than those obtained by Boyles et al. (2010). None of the studies found significant differences in patient satisfaction between the techniques.

#### 4.1. Limitations

There are limitations to consider when interpreting the results of this study. The first relates to the number of patients. We only included 61 patients in this study, but post hoc analyses suggested that we were adequately powered to identify an interaction if it had existed. Second, while patients were not told which MT they received, we did not assess the extent to which they remained blinded. We did not collect other factors that very recent papers have suggested might play a role in pain relief – factors such as the therapist's equipoise, and the therapeutic alliance between patient and therapist. However, we believe that these issues may not have been pertinent in our study as there was no intervention with superior outcomes that might related to either factor.

The long follow-up period (3 months) and the conditions required by the study (receiving no other treatment) may have caused a loss of participants. However, the primary reason for dropping out given by the patients was that they had improved very much and they did not want to continue with the study.

Another limitation is the limited number of treatment sessions (four). There is little evidence about optimal doses for MT and in a clinical setting more sessions are applied. This raises the question of whether a larger number of sessions would have resulted in different outcomes. Lastly, all participants were residents in one area of Coslada with subsequent similarity at an economic–social–cultural level, making it difficult to generalize the results to other populations that differ from that group.

## 5. Conclusion

This study revealed no superiority of HVLA, Mob or SNAG in outcomes, namely neck pain, disability, motion and global perception of change in the short term (3 months). Any one of the three techniques is as effective as the others. It is possible that studies using different treatment doses may show different results. Statistically and clinically significant improvements in outcomes in all groups over three months confirm that all the MT techniques proposed in this study can be considered for neck pain management. Further studies are necessary to investigate whether more sessions, longer follow-up and combinations of different techniques have different effects.

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