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Prevention and Rehabilitation

Effect of adding stretching to standardized procedures on cervical range of motion, pain, and disability in patients with non-specific mechanical neck pain: A randomized clinical trial

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ABSTRACT

Objective: to investigate the benefit of adding stretching exercises to cervical joint mobilization and active rotation exercises for patients with non-specific mechanical neck pain.
Methods: Thirty-eight subjects with non-specific mechanical neck pain were randomly assigned to a standard procedure group (passive cervical mobilization and active cervical rotation range of motion exercise) or a combined procedure (passive cervical mobilization, active cervical rotation range of motion exercises, and stretching procedures). Mixed factorial analysis of variance was used to compare changes between groups over time in active cervical range of motion, Numeric Pain Rating Scale, Neck Disability Index, Global Rating of Change, and Pressure Pain Threshold.
Results: There was a significant change in mean active range of motion in all directions, Pressure Pain Threshold, perceived pain, disability levels, and global rating of change over time ($p < 0.001$). There was a significant group by time interaction in mean active range of motion during extension ($p = 0.01$), right rotation ($p = 0.004$), right and left lateral flexion ($p = 0.05$, and $p = 0.02$ respectively). However, there was no significant group by time interaction in mean active range of motion during flexion, left rotation, pain intensity ($p = 0.09$), right and left pressure pain threshold ($p = 0.30$, 0.47, respectively), and disability ($p = 0.07$).
Conclusions: Both study groups improved significantly in all subjective and objective outcome measures. However, data from this study suggest that adding stretching to the standard procedures may be more effective than the standard procedure alone at improving cervical extension, right rotation, and lateral flexion active range of motion, but not pain and disability.

1. Introduction

Neck pain is becoming one of the leading causes of musculoskeletal disorders in the general adult population (Bot et al., 2005). Its prevalence ranges from approximately 20-50% of the population with higher occurrence in women than men (Cheng et al., 2015; Snodgrass et al., 2014). The reported prevalence of non-specific mechanical neck pain (NSMNP) disorders is attributed to the undetermined origin as well as the poor prognosis of the disorder (Binder, 2007; Paksaichol et al., 2012; Häkkinen et al., 2007). It has been suggested that NSMNP might occur due to interaction of multiple etiological dimensions such as pathoanatomical, neuromuscular and psychosocial factors (Binder, 2007; Paksaichol et al., 2012). Also, the poor prognosis for neck pain is related to the experience of persistent pain and disability in many neck pain sufferers following therapeutic procedure (Häkkinen et al., 2007). Non-specific neck pain is defined as posterolateral cervical pain without structural pathology and underlying disease (Hidalgo et al., 2017; Remmen et al., 2013). Individuals with NSMNP often suffer from pain, restriction of cervical joint range of motion (Jaeschke et al., 1989), limited functional activity, participation restrictions

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and reduced quality of life (Sihawong et al., 2011; Green, 2008). The associated symptoms have exerted socioeconomic issues on patients' well-being and the healthcare system (Ariëns et al., 2002; Leininger et al., 2018). The costs related with treating neck pain disorders are approximately 0.05%–2% of gross national product (Cheng et al., 2015), and it is expected to grow exponentially (Ariëns et al., 2002). Therefore, numerous studies have investigated the efficacy of procedures aiming to alleviate non-specific mechanical neck pain and associated dysfunctions (Kietrys et al., 2007; Blangsted et al., 2008; Blanpied et al., 2017).

Manual therapy procedures, manipulation and joint mobilizations, to the cervical spine have been determined to be equally effective in the treatment of NSNP (Gross et al 2004, 2015; Hurwitz et al., 2002). Combining manual therapy with exercise has better patient outcomes than either alone making them the criterion or gold standard for treating (NSMNP) (Gross et al., 2004; Hoving et al., 2006). Hidalgo et al., (2017) identified studies utilizing four different forms of cervical manual therapy that pair well with exercise: 1) high-velocity low-amplitude thrust manipulation, 2) joint mobilizations with soft-tissue procedures, 3) manipulation plus mobilizations, and 4) mobilizations with movement (Hidalgo et al., 2017). They then compared these different forms of manual therapy with exercise (Hidalgo et al., 2017). In contrast, the comparative forms of exercise in systematic reviews were combined even though they were not homogeneous including active cervical range of motion, strengthening, endurance, cervical stabilization, cardiovascular, and scapular stabilization exercises (Hidalgo et al., 2017; Miller et al., 2010). Despite the fact that manual therapy and exercise are considered the criterion standard for treating patients with neck pain (Gross et al., 2004; Hoving et al., 2006), not everyone is in agreement (Fredin and Loras, 2017). In a recent systematic review and meta-analysis, the authors reported that combining supplemental manual therapy did little to improve the treatment effect of exercise alone for pain reduction in patients with activity limitations due to pain (Fredin and Loras, 2017). Again, the exercises prescribed in the seven studies utilized in this systematic review varied greatly (Fredin and Loras, 2017).

Due to the rare but potentially serious adverse effects associated with cervical trust manipulations, minimally invasive non-thrust cervical mobilizations may be a safer and equally effective option for short-term pain modulation (Blanpied et al., 2017; Gross et al., 2004, 2015). However, not everyone is in agreement that cervical joint mobilization is one of the criterion standards for treating neck pain. In a randomized clinical trial, Ylinen et al., (2005), reported that the combined procedures of cervical mobilization, massage and self-administered stretching exercises do not differ significantly when compared with therapist-administered stretching procedures alone in reducing neck pain (Hakkinen et al., 2007). Stretches were performed to the following muscles: upper trapezius, scalenes, levator scapulae, pectoralis major and pectoralis minor (Häkkinen et al., 2007). Similarly, Childs et al., recommended that resolving muscle length deficits for patients with neck pain might add benefit to the holistic plan of care (Childs et al., 2008). In this clinical practice guidelines, they recommended that the following muscles be tested for tightness and subsequently stretched in patients with neck pain: anterior/middle/posterior scalene, upper trapezius, levator scapula, pectoralis major, and pectoralis minor; however, this recommendation is based on weak evidence (Childs et al., 2008). Despite the limited evidence, adding stretching exercise is still recommended in the early care for patients with neck pain due to the associated reduced cost (Childs et al., 2008). This has created confusion among therapists in determining which combination of procedures impact outcomes most efficiently in patients with neck pain (Häkkinen et al., 2007; Childs et al., 2008).

To our knowledge, there are no studies investigating the effect of adding therapist-administered stretching as a supplement to the criterion standard of cervical joint mobilization and active cervical rotation range of motion (ACRROM) exercises in patients with non-specific mechanical neck pain. Thus, the purpose of this study was to compare the efficacy of integrating stretching procedures with passive cervical mobilization and active range of motion exercise versus standard procedure on cervical active range of motion (AROM), self-reported pain level, pressure pain threshold, disability and satisfaction of patients with non-specific mechanical neck pain. We hypothesized that the combined procedure would be more efficacious than the standard procedure at improving pain level, cervical AROM, pressure pain threshold, disability and satisfaction level in patients with non-specific mechanical neck pain.

2. Methods

2.1. Participants

Participants were recruited through flyers, posters and word of mouth from San Bernardino and Riverside Counties (CA, USA), and emails from Loma Linda Community (University and Medical Center). Forty-three participants who had at least two weeks of non-specific mechanical neck pain were randomly assigned to either the combined procedure (passive cervical mobilization, active range of motion exercises, and stretching procedures) ($n_1 = 20$) or standard procedure group (passive cervical mobilization and active range of motion exercises) ($n_2 = 23$) using a random number generator. All participants read and signed a consent form that was approved by the institutional review board at Loma Linda University. This study was registered in ClinicalTrials.gov with Protocol #5160230. The participants met the following inclusion criteria: between 18 and 60 years of age, had non-specific neck pain for at least 2 weeks, and pain intensity of more than 2 points on a numeric pain rating scale (NPRS) in the past week. Participants were excluded from the study if they reported/had one or more of the following conditions: specific diagnosis of the cervical spine (e.g., spinal stenosis, disc prolapse), previous surgery to the neck and shoulder areas, shoulder pathology (e.g., bursitis, tendonitis, adhesive capsulitis), history of severe trauma (e.g, whiplash associated disorders), ligamentous instability, hypermobility syndrome, migraine (frequency more than twice per month), spasmodic torticollis, radiculopathy due to peripheral nerve entrapment, fibromyalgia, chronic neck pain dominated by psychosocial factors, severe psychiatric illness, inflammatory rheumatic diseases, and pregnancy.

The identification of the study's excluding criteria was conducted through clinical examination, medical history, and self-reported questionnaires (Häkkinen et al., 2007). Demographic and general characteristics of the participants are presented in Table 1. The study took place at the orthopedic physical therapy laboratory at Loma Linda University.

2.2. Instrumentation

2.2.1. Specific objective outcomes: active cervical ROM

The Gravity Inclinometer method using the Cervical Range of Motion (CROM) device was used to assess cervical AROM: flexion, extension, lateral flexion, and rotation. The CROM was used in many clinical trials and deemed to have good reliability and validity (Williams et al., 2010). Lee et al., (2004) indicated that the CROM device has high intra-examiner reliability with an ICC ranging from 0.74 to 0.84. The CROM device has high concurrent validity compared to radiograph (Tousignant et al., 2000). Williams et al., (2010) reported that CROM device has high validity with correlation coefficient (r) of 0.97.

Table 1
Mean (SD) of general characteristics (N = 38).

	Combined Procedure ($n_1 = 18$)	Standard Procedure ($n_2 = 20$)
Female; n (%)	12 (66.7%)	12 (60%)
Age (years)	31.4 (9.0)	30.6 (7.8)
Height (m)	1.6 (0.1)	1.7 (0.1)
Weight (kg)	68.0 (17.9)	77.1 (16.5)
BMI (kg/m^2)	25.8 (5.5)	28.0 (7.5)
Attendance Rate (%)	100 (0)	100 (0)
Exercise Compliance Rate (%); Median (min, max)	100 (70, 100)	100 (80, 100)

Abbreviations: SD, Standard deviation, m, meter, kg, kilogram.

In order to measure cervical AROM, the participant sat on a stool facing the west, feet flat on floor, and arms hanging at each side. One examiner positioned the CROM device on the participant's head. Then 3 trials were recorded for six different directions: flexion, extension, right and left lateral flexion, and left and right rotation. The other examiner then recorded the average of the three trails for each position.

2.2.2. Pressure Pain Threshold

The digital algometer is an electronic device used to measure the amount of force that is required to produce pain or pressure pain threshold (PPT) (Ylinen et al., 2005). It has high reliability and validity in measuring pain threshold for individuals with neck pain. Park et al., (2011) indicated that pressure algometry has a high intra rater reliability (ICC ranging from 0.94 to 0.98). The validity of the electric algometer ranged from r = 0.95 to 0.98 (Vaughan et al., 2007). Another study showed that intra rater reliability was excellent while inter rater reliability was substantial for both healthy subjects and subjects with neck pain for the upper trapezius location (Walton et al., 2011).

In order to measure neck pressure pain threshold, a handheld electronic pressure algometer with a surface area at the round tip of 1 cm^2 was utilized. The participant laid prone on a treatment table and was instructed to report the first point when pressure sensation turned into pain sensation. The examiner increased the pressure gradually at rate of 1 kg/s perpendicularly to the right upper trapezius at the upper border of muscle between the lateral border of acromion and the midline and then on the left side with a 30-s pause between each trial (Ylinen et al., 2005). Three trials were performed at each side in each test session (Celenay et al., 2016).

2.2.3. Primary subjective outcomes: numeric pain rating scale

Numeric pain rating scale (NPRS) was used to determine the level of the participant's pain. It consists of a straight 100 mm line that is scored from 0 to 100 with 10 mm intervals. The zero represents no pain while a 100 represents very severe pain. The NPRS has moderate test-retest reliability with correlation coefficients ranging from 0.60 to 0.77 (Boonstra et al., 2008). In addition, Boonstra et al., (2008) indicated that the NPRS has moderate to high validity in detecting pain with correlation coefficients ranging from 0.64 to 0.84.

2.2.4. Neck Disability Index

The Neck Disability Index (NDI) consists of ten items that each range from 0 to 5 intended to measure the level of disability for patients with neck pain. The NDI score ranges from 0 to 50 (Cleland et al., 2008). The level of disability is determined by the total score of the NDI as follows: 0–4 = no disability, 5–14 = mild, 15–24 = moderate, 25–34 = severe, and above 34 = complete disability (Vernon, 2008). The NDI has a high test-retest reliability with an intra class correlation (ICC) between 0.88 and 0.95 and high internal consistency with Cronbach's α values ranging from 0.85 to 0.90 (Salo et al., 2010). For NDI, the ICC was 0.83 (95% CI, 0.75–0.90), which indicates that the NDI has high validity to detect any small change in the patient's condition (Cleland et al., 2008). In addition, Childs et al., (2008) reported that the NDI has high sensitivity and specificity of 0.83 and 0.72, respectively.

2.2.5. Secondary subjective outcomes: global rating of change

The Global Rating of Change is used to measure the amount of perceived improvement that the patient achieves from the rehabilitation program. The score ranges from −7 to 7 in which −/+3 to −/+ 1 represents a small change, −/+ 4 to −/+5 represents moderate change and −/+6 to −/+7 means a large change. The negative and positive signs determine whether the patient's condition worsens or improves respectively. The GROC has a high test-retest reliability with an ICC value of 0.90 (95% confidence interval (CI) 0.84 to 0.93). In addition, the GROC has high face validity with Pearson's r = 0.72–0.90 and ICC = 0.74 (Salo et al., 2010). Kamper et al., (2009) reported that the GROC has high construct validity when compared to other gold standard measurements such as the Roland Morris, Oswestry, and pain rating scale. For this study we set +5 (“Quite a bit better”) as a cut-off for a successful outcome.

2.3. Procedures

The study was conducted over 8 weeks. Participants were randomly allocated into two groups: *combined procedure* (passive cervical mobilization, ACRROM exercises, and stretching procedures) ($n_1 = 18$) and *standard procedure groups* (passive cervical mobilization and ACRROM exercises) ($n_2 = 20$). Group assignment was conducted by an independent person using a random number generator and concealed in “sealed envelopes” from all personnel involved in screening before randomization. Post randomization, objective measures assessors were blinded to group assignment. Participants in the *combined procedure group* received passive manual therapy consists of 15 min of cervical mobilization, 15 min of manual stretching, and 10 min of supervised ACRROM exercises for 2 sessions per week for 4 weeks. In addition, subjects in the combined procedure group received a home exercise program consisting of ACRROM exercises (performed 3–4 times daily) as well as a self-administered stretching exercise program (performed 5 times a week). Participants in *standard procedure group* received 15 min of cervical mobilization, 10 min of supervised ACRROM exercises and a home exercise program consisting of ACRROM exercises (performed 3–4 times daily). Refer to appendix I.

Cervical Mobilization procedures were used in the study and consisted of the following low-velocity non-thrust cervical joint mobilizations for either unilateral or bilateral symptoms: posteroanteroior (PA) central vertebral pressures (CVP), PA unilateral vertebral pressure (UVP), lateral glides (translation sideways), and passive physiological cervical rotation. These procedures were modified from prior published studies (Häkkinen et al., 2007). In a recent systematic review, Hidalgo et al., (2017) established that

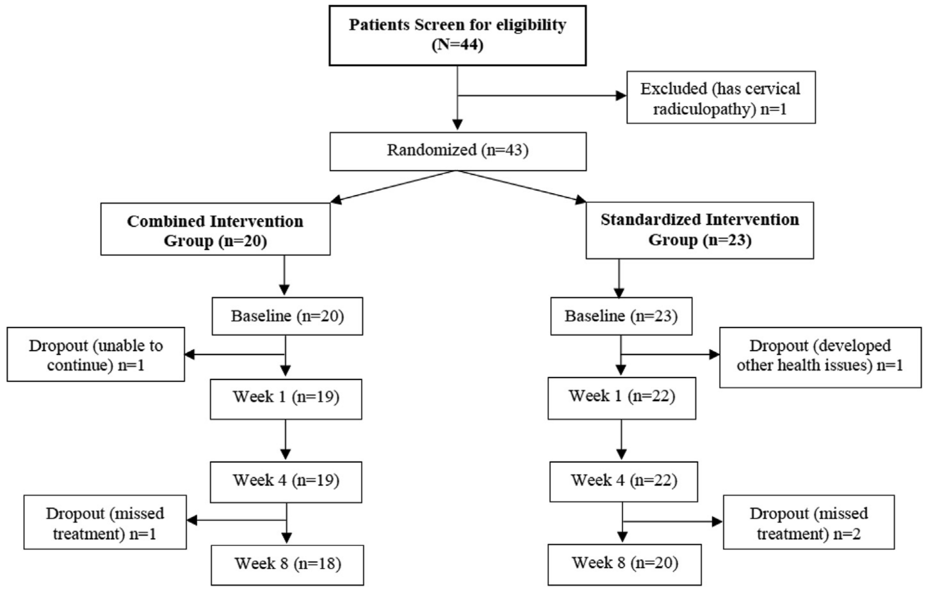

Fig. 1. Flow diagram of participants' recruitment and retention.

cervical joint mobilizations need not be applied to the symptomatic segment to achieve the same positive patient outcome. Despite this important finding, in this study we opted to target the symptomatic side and level when applying joint mobilizations in this study.

Active Cervical Rotation Range of Motion Exercises were performed under supervision for 2 sessions per week for 4 weeks, and independently for 10 repetitions 3–4 times daily. The ACRROM exercise consisted of the subject placing four fingers over the manubrium bone and placing chin on the fingers. The subject was then instructed to rotate to one side as far as possible and return to neutral and then actively rotate to the other side (Cleland et al., 2007). Subjects were advised to maintain their usual activity within the limits of pain and keep exercises diary to track the frequency.

Stretching procedures were performed in the combined procedure group for 30 s for each muscle and repeated 3 times twice a week to the following muscles: anterior, middle and posterior scalene, upper fibers of trapezius, pectoralis minor muscles and interspinous muscles as described by Ylinen et al., (2008).

The cervical mobilization and stretching exercise procedures were performed by a licensed physical therapist who has 6 years of experience in manual physical therapy.

Self-administered stretching exercises were performed by participants in the combined procedure group to the following muscles: the cervical extensor muscles, the upper fibers of the trapezius, and the posterior scalene as described by Häkkinen et al., (2007). Each movement was held for 30 s and repeated 3 times. Lastly, the participant was instructed to perform a neck straightening exercise by retracting the neck (Chin tucks) 5 times for 3–5 s (Hakkinen, 2007). Subjects in the combined procedure group were provided with written instruction of the stretching exercises and directed to perform stretching exercise 5 times a week, each exercise session takes about 10 min. Patients were also instructed to keep a stretching diary to track their stretch exercise frequency.

2.4. Data collection

Data was collected at baseline, one week after the procedure, and at week 4. The final data collection date was set at week 8 as a follow up to determine whether the participant was able to maintain gains at one month following the procedures.

2.5. Statistical analyses

Data was summarized using mean and standard deviation for quantitative variables and counts (%) for qualitative variables. The normality of continuous variables was examined using Shapiro Wilk's test. The distribution of the participants' characteristics by study group were evaluated using chi-square for qualitative variables and independent t-test for quantitative variables. A 2-group x 4-time points (baseline, week 1, week 4, and week 8) mixed factorial analysis of variance (ANOVA) was used to examine changes in cervical AROM variables, pressure pain threshold, NPRS, GROC, and NDI scores by study group over time.

The primary analysis included a comparison between groups using the group × time interaction effect in the mixed factorial ANOVA. If the interaction was statistically significant, change from baseline was compared between groups at each follow-up time point using an independent *t*-test. If the interaction was not statistically significant, the between-groups comparison was considered not statistically significant at any time point. However, if the main effect of time was significant in the mixed factorial ANOVA, bonferroni post hoc test was conducted on the combined groups.

The secondary analysis included testing of change from baseline at each time point within-groups using one-way repeated measures ANOVA. If the results of the test were statistically significant, post hoc testing using Bonferroni test was conducted on each study group separately. The level of significance was set at $p \leq 0.05$. Statistical analysis was performed using IBM SPSS Software version 24 for Windows (Chicago, IL, USA).

2.6. Sample size estimate

A sample size of 50 participants was estimated using a moderate effect size for the group × time interaction ($f = 0.25$ or partial $\eta^2 = 0.06$) (Lakens, 2013), level of significance ($\alpha = 0.05$), and power of 0.80. The α level was set at 0.05 for all omnibus (overall) tests of significance. A total of 43 participants were enrolled.

3. Results

At week 1 follow-up, 2 participants dropped out of the study

Table 2
Mean (SD) cervical range of motion (°) by study group over time (N = 38).

	Combined Procedure Group ($n_1 = 18$)				Standard Procedure Group ($n_2 = 20$)						
	Baseline	One week later	4 weeks later	8 weeks later (4 weeks follow-up)	Baseline	One week later	4 weeks later	8 weeks later (4 weeks follow-up)	p-value over time*	p-value (groupxtime)*	η2
Flexion	44.4 (11.0)	51.3 (10.7)	54.1 (11.3)	53.9 (9.6)	45.1 (8.9)	47.7 (9.0)	53.9 (10.0)	53.2 (10.7)	<0.001	0.512	0.03
Extension[a]	69.8 (14.1)	76.4 (11.5)	82.0 (10.1)	79.2 (11.0)	70.5 (9.7)	74.1 (15.5)	71.3 (14.9)	74.5 (16.7)	0.001	0.010	0.11
Right Rotation[b]	64.7 (13.3)	71.9 (13.7)	73.2 (15.2)	78.5 (9.8)	68.1 (10.6)	70.2 (9.8)	76.2 (10.4)	71.5 (11.4)	<0.001	0.004	0.14
Left Rotation	59.4 (17.1)	66.2 (11.8)	73.1 (8.9)	72.9 (9.5)	63.8 (9.7)	69.1 (10.0)	71.9 (10.4)	71.3 (9.5)	<0.001	0.091	0.05
Right Lateral Flexion[c]	41.7 (11.4)	46.9 (7.7)	51.1 (9.1)	51.2 (9.4)	41.7 (5.9)	42.3 (7.9)	45.2 (6.4)	47.3 (7.8)	<0.001	0.050	0.06
Left Lateral Flexion[d]	42.9 (8.3)	48.8 (7.3)	52.1 (9.9)	55.3 (10.2)	42.5 (6.6)	43.7 (6.1)	45.7 (7.6)	47.4 (7.9)	<0.001	0.023	0.10

Abbreviations: SD, Standard Deviation. η^2, partial eta squared for the group × time interaction.
*Mixed Factorial ANOVA, level of significance was set at $p \leq 0.05$.
[a] Significant difference between baseline & week 4 (p = 0.01) and baseline & week 8 (p = 0.04) in the combined group.
[b] Significant difference between baseline & week 8 (p = 0.001) and weeks 1 & 8 (p = 0.03) in the combined group, and significant difference between baseline & week 4 (p = 0.006), weeks 1 & 4 (p = 0.01) and weeks 4 & 8 (p = 0.03) in the standard group.
[c] Significant difference between baseline & week 4 (p = 0.01), baseline & week 8 (p = 0.03), and weeks 1 & 4 (p = 0.01) in the combined group, and significant difference between baseline & week 8 (p = 0.02) in the standard group.
[d] Significant difference between baseline & week 4 (p = 0.01) and baseline & week 8 (p = 0.001) in the combined group, and significant difference between baseline & week 8 (p = 0.01) in the standard group.

Table 3
Mean (SD) of pain threshold (lbs), and pain, satisfaction, and neck disability index scores by study group over time (N = 38).

	Combined Procedure Group ($n_1 = 18$)				Standard Procedure Group ($n_2 = 20$)						
	Baseline	One week later	4 weeks later	8 weeks later	Baseline	One week later	4 weeks later	8 weeks later	p-value over time*	p-value (groupxtime)*	Partial Eta Squared (η^2)
Right Pain Threshold	4.5 (1.7)	4.6 (1.2)	5.5 (1.9)	5.8 (2.2)	4.9 (2.2)	4.4 (1.9)	5.0 (1.9)	4.9 (1.6)	0.060	0.304	0.04
Left Pain Threshold	4.0 (1.5)	4.3 (1.1)	5.4 (2.4)	5.5 (2.8)	4.7 (1.9)	4.0 (1.3)	5.1 (2.1)	5.4 (2.3)	0.001	0.471	0.03
Numeric Pain Rating Scale	5.2 (1.8)	3.9 (2.1)	1.8 (1.8)	1.5 (1.8)	4.1 (1.5)	2.9 (1.4)	1.8 (2.1)	1.8 (2.6)	<0.001	0.092	0.06
Global Rate of Change	_	2.8 (2.4)	5.0 (2.1)	4.9 (2.3)	_	2.1 (2.0)	4.5 (2.7)	3.3 (4.1)	<0.001	0.370	0.03
Neck Disability Index	12.9 (6.0)	7.6 (4.7)	3.9 (3.6)	3.7 (4.1)	10.9 (3.1)	9.0 (3.8)	5.7 (6.7)	6.5 (10.5)	<0.001	0.091	0.06

Abbreviations: SD, Standard Deviation.
*Mixed Factorial ANOVA, level of significance was set at $p \leq 0.05$.

Table 4
Mean (SD) changes from Baseline by Study Group.

Variable	Time Change from Baseline	Combined Procedure Group (n1 = 18)	Standard Procedure Group (n2 = 20)	Mean Difference (95% CI)	p Value*	Effect Size (Cohen's d)
Extension	Week1	6.6 (11.4)	3.6 (11.6)	3.0 (−5.1, 11.0)	0.464	0.30
	Week 4	12.2 (11.9)	0.8 (10.3)	11.4 (3.3, 19.4)	0.007	1.02
	Week 8	9.4 (11.5)	4.0 (11.7)	5.4 (−2.9, 13.8)	0.192	0.50
Right Rotation	Week 1	7.2 (10.5)	2.0 (6.4)	5.2 (−1.4, 11.5)	0.117	0.60
	Week 4	8.5 (13.2)	8.1 (8.0)	0.4 (−7.9, 8.7)	0.916	0.04
	Week 8	13.7 (8.8)	3.3 (7.7)	10.4 (4.4, 16.4)	0.001	1.26
Right Lateral Flexion	Week 1	5.2 (9.8)	0.6 (6.6)	4.6 (−1.7, 10.9)	0.143	0.55
	Week 4	9.4 (8.9)	3.5 (5.7)	5.9 (0.4, 11.4)	0.037	0.79
	Week 8	9.4 (10.8)	5.6 (6.7)	3.8 (−2.6, 10.5)	0.235	0.42
Left Lateral Flexion	Week 1	5.9 (8.3)	1.2 (5.1)	4.7 (−0.1, 9.5)	0.057	0.68
	Week 4	9.2 (8.5)	3.2 (4.8)	6.0 (0.9, 11.1)	0.023	0.87
	Week 8	12.4 (9.6)	4.9 (5.6)	7.5 (1.8, 13.1)	0.011	0.95

Abbreviation: SD, Standard Deviation; CI, Confidence Interval.
*Independent *t*-Test.

due to health conditions, and at week 8, 3 participants withdrew (Refer to Fig. 1). Thus, 38 participants with a mean age 31.0 ± 8.3 years old, height 1.6 ± 0.1 m, mass 72.8 ± 17.5 kg, and body mass index (BMI) 26.9 ± 6.7 kg/m^2 completed this study. Sixty five percent of the participants were females (n = 24). The mean attendance rate was 100% for all participants. The median compliance rate of home stretching exercise for both study groups was 100%. In addition, none of the participant reported receiving any extra care during the study period. Demographic and general characteristics are presented in Table 1.

3.1. Between-groups analysis

Results of the mixed factorial ANOVA are displayed in Table 2. During flexion AROM, there was no significant group by time interaction ($p = 0.512$), however, there was a significant change over time ($p < 0.001$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 1 ($p = 0.002$), baseline and week 4 ($p < 0.001$), and baseline and week 8 ($p < 0.001$). For extension AROM, there was a significant group by time interaction ($p = 0.010$, $\eta^2 = 0.11$). Results of the independent *t*-test showed that there was a significant difference between the two groups at week 4 ($p = 0.01$), but not for the other time points (Refer to Table 4).

For right rotation AROM, there was a significant group by time interaction ($p = 0.004$, $\eta^2 = 0.14$). Results of the independent *t*-test showed that there was a significant difference between the two groups at week 8 ($p < 0.001$), but not for the other time points (Refer to Table 4). During left rotation, there was no significant group by time interaction ($p = 0.091$), however, there was a significant change over time ($p < 0.001$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 1 ($p = 0.01$), baseline and week 4 ($p < 0.001$), and baseline and week 8 ($p < 0.001$) (Refer to Table 2).

For right lateral flexion AROM, there was a significant group by time interaction ($p = 0.050$, $\eta^2 = 0.06$). Results of the independent *t*-test showed that there was a significant difference between the two groups at week 4 ($p = 0.04$), but not for the other time points (Refer to Table 4). For left lateral flexion AROM, there was a significant group by time interaction ($p = 0.023$, $\eta^2 = 0.10$). Results of the independent *t*-test showed that there was a significant difference between the two groups at week 4 and 8 ($p = 0.04$, $p = 0.005$, respectively), but not week 1 ($p = 0.07$) (Refer to Table 4).

For right upper trapezius muscle PPT, there was no significant group by time interaction ($p = 0.304$) and no significant change over time ($p = 0.06$). For left upper trapezius muscle PPT, there was no significant group by time interaction ($p = 0.471$), however, there was a significant change over time ($p = 0.001$). Bonferroni post hoc comparison revealed that the difference was significant between week 1 and week 4 ($p = 0.02$), and between week 1 and week 8 ($p = 0.03$) (Refer to Table 3).

For NPRS, there was no significant group by time interaction ($p = 0.092$), however, there was a significant change over time ($p < 0.001$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 1 ($p = 0.02$), baseline and week 4 ($p < 0.001$), and baseline and week 8 ($p < 0.001$) (Refer to Table 3). For NDI, there was no significant group by time interaction ($p = 0.091$), however, there was a significant change over time ($p < 0.001$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 1 ($p = 0.02$), baseline and week 4 ($p < 0.001$), and between baseline and week 8 ($p < 0.001$). (Refer to Table 3). For GROC, there was no significant group by time interaction ($p = 0.370$), however, there was a significant change over time ($p < 0.001$). Bonferroni post hoc comparison revealed that the change was significant between week 1 and week 4 ($p < 0.001$), and between week1 and week 8 ($p = 0.02$) (Refer to Table 3).

3.2. Within-groups analysis

Results of the one-way repeated measures ANOVA are displayed in Table 2. For extension AROM in the combined procedure group, there was a significant change over time ($p < 0.001$, $\eta^2 = 0.35$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 4 ($p = 0.01$) and baseline and week 8 ($p = 0.04$). However, in the standard procedure group, there was no significant change over time ($p = 0.27$).

For right rotation AROM in the combined procedure group, there was a significant change over time ($p < 0.001$, $\eta^2 = 0.37$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 8 ($p < 0.001$) and between weeks 1 and 8 ($p = 0.03$). Also, in the standard procedure group, there was significant change over time ($p < 0.001$, $\eta^2 = 0.34$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 4 ($p = 0.006$), between weeks 1 and 4 ($p = 0.01$) and weeks 4 and 8 ($p = 0.03$).

For right lateral flexion AROM in the combined procedure group, there was a significant change over time ($p < 0.001$, $\eta^2 = 0.37$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 4 ($p = 0.01$), between baseline and week 8 ($p = 0.03$) and between weeks 1 and 4 ($p = 0.01$). In addition, in the standard procedure group, there was significant change over time ($p < 0.001$, $\eta^2 = 0.31$). Bonferroni post hoc comparison revealed that the change was only significant between baseline and week 8 ($p = 0.02$). For left lateral flexion AROM in the combined procedure group, there was a significant change over time ($p < 0.001$, $\eta^2 = 0.45$). Bonferroni post hoc comparison revealed that the change was significant between baseline and week 4 ($p = 0.01$) and between baseline and week 8 ($p = 0.001$). Furthermore, in the standard procedure group, there was significant change over time ($p = 0.002$, $\eta^2 = 0.26$). Bonferroni post hoc comparison revealed that the change was only significant between baseline and week 8 ($p = 0.01$).

4. Discussion

4.1. Active cervical range of motion

Both groups had a significant improvement in ACROM for flexion, bilateral rotation and lateral flexion over time. Only the combined procedure group, however, had a significant improvement in ACROM for extension over time. Nevertheless, when comparing both groups at week 4, the mean extension ACROM was significantly higher by 11.4° in favor of the combined procedure group. Specifically, the combined procedure group improved by (12.2°) from baseline, whereas the standard procedure group had no improvement (0.8°). An increase of ≥11.1° from baseline is considered to be clinically important as reported by Hoving et al., (2005), and this was noted in the combined procedure group. Additionally, at week 8, mean left lateral flexion and right rotation ACROMs were greater in the combined procedure group by (7.5° and 10.4°, respectively). In particular, the combined procedure group improved by (12.4° and 13.7°, respectively) which also exceeded the level of clinical importance of (10.4° and 13.5°, respectively) (Hoving et al., 2005); in contrast, the standard procedure group improved by only (4.9° and 3.3°, respectively). Furthermore, at week 4, the mean right and left lateral flexion ACROMs for the combined procedure group were significantly higher by (5.9° and 6.0°) than the standard procedure group. Though the mean differences between groups were statistically significant, the change from baseline between groups did not reach the level of clinical importance as outlined by Hoving et al., (2005). The combined procedure group had improved by (9.4°, 9.2°) from baseline while the standard procedure group (3.5°, 3.2°).

The improvements in ACROMs in this study were quite similar to those reported by Hanneya et al., (2017). Previous studies attributed the improvement in cervical extension and bilateral lateral flexion in manual stretching groups to the reduction of pain level as a result of the release of trigger point of upper trapezius when stretching procedures were applied (Hanneya et al., 2017; Andersen et al., 2011). However, in the present study, both groups had a significant reduction in pain level and left upper trapezius pressure pain threshold over time with no reported differences between groups. Despite that, only the combined procedure group showed a significant improvement in cervical extension, right rotation and bilateral lateral flexion ACROM, which might be attributed to something other than the reduced pain level alone. A possible explanation for the improvement seen in the combined procedure group could be credited to the mechanical effect of stretching on muscle viscoelasticity/extensibility and joint structures which might have led to the noted increase in ACROM.

In our study, the anterior and middle scalenes were stretched bilaterally during the procedure period. Anterior scalenes work bilaterally to flex the neck and thus stretching these muscles might explain the noted improvement in cervical extension ACROM. Anterior, middle, posterior scalenes and upper trapezius work unilaterally to move the neck into same sided lateral flexion direction and therefore stretching these muscles might explain the noted improvement in active cervical lateral flexion away from the stretch side. Upper trapezius also works unilaterally to rotate the neck into same sided rotation thus stretching these muscles might explain the noted improvement in active cervical rotation.

In addition to the mechanical factors, the effect of muscle stretching may occur due to the neurophysiological changes. Recent evidence has shown that muscle stretching suppresses monosynaptic spinal reflex excitability in the stretched muscle leading to an increase in the tissue extensibility of the muscle. This might also explain the noted increase in ACROM in the combined group (Masugi et al., 2017).

Furthermore, passive stretching has been shown to reduce pain and muscle stiffness.[44] Both groups in our study had similar reductions in pain. Furthermore, a reduction in passive stiffness is transient, lasting from one to 24 h (Riley and Van Dyke, 2012). The gains in active cervical extension and lateral flexion were still present one month after the end of the stretching procedure suggesting a mechanism other than a reduction of muscle stiffness. Muscle can lengthen through the addition of sacromeres; however, this is only thought to occur when a contractile activity occurs during stretching (active stretching) (Riley and Van Dyke, 2012). In our study, subjects received passive stretching only. Regardless of the underlying mechanism for contractile or connective tissue changes from stretching, adding stretching of the above-mentioned muscles in addition to the criterion standard improves active cervical extension, lateral flexion motion and right rotation.

4.2. Pain, disability and patient's satisfaction

At all 3-time points, NPRS and left PPT improved in both groups. The right pressure pain threshold, however, did not show a significant change. In addition, the difference was not significant between the groups. Similar improvement in NPRS and PPT for both groups may reflect patients' experience of the efficacy of manual treatment/mobilization procedures in reducing cervical pain, which was also reported elsewhere by patients' expectations were shown to influence therapy outcomes and getting hands-on procedures might contribute to the results (Kjellman et al., 2002).

The NDI scores improved overtime in both groups at all 3-time points, but it was not significantly different between the two groups. It is important to note that the majority of the participants in our study had only mild disability ranging between 5 and 14 points; which might explain why the difference between groups were not significant. However, it is important to note that the NDI score at week-8 in the combined procedure group decreased by 9.2 points, exceeding the minimal detectable change reported in literature of 5 points (Childs et al., 2008), while the standard procedure group dropped by only 4.4 points. In addition, the NDI score of the combined procedure group at week-8 reached the minimal clinically important difference (5–9.5 points) (Childs et al., 2008), which represents the smallest amount of change that is clinically meaningful by patients. This can also support the benefit of adding stretching exercises to mobilization when compared with sole intervention.

Finally, the GROC scores showed significant improvement overtime in both groups, but not between groups. This is in line with a previous report by Hidalgo et al., (2017). The authors found greater reduction in self-reported pain, improvement in function, quality of life and patient satisfaction in combined procedure group, manual therapy and exercise, than when compared with sole procedure group or manipulation in adults with neck pain. In our study, at week 4, the combined procedure group and the standard procedure group were equally satisfied with their treatment outcomes (moderate positive change = +4 to +5) with mean scores of 5.0 and 4.5, respectively (See Table 4). Four weeks following the procedure (week 8), the combined procedure group still reported a moderate positive change (mean = 4.9), while the standard procedure group reported a small positive change (mean = 3.3). Although not significantly different, only the combined group met our minimal criteria for success of +5 ("Quite a bit better"). The subjects in the combined group may have been more satisfied due to the increased time of hands-on procedure. The effect of hands-on procedure is shown to influence therapy outcomes as described previously (Kjellman et al., 2002).

Manual therapy findings are too frequently described as only primary subjective outcomes such as pain relief (e.g., pain and disability reduction) or secondary subjective outcomes such as global perceived effect (e.g., GROC, fear avoidance) rather than specific objective outcomes such as range of motion and trigger point tenderness. A strength of this study was adding objective measures to enrich the outcome profiles (Oostendorp, 2018).

4.3. Study limitations

This study had some limitations. A short follow up period was one of the study's limitations as extended follow-up would provide valuable information regarding which procedure had lasting effect on reducing pain and improving patient's function. However, sole manual therapy for neck pain has not been shown to have lasting effects in contrast to cervical muscle training combined with stretching exercises (Ylinen et al., 2003). Also. we did not have a control group, nor we included a stretching alone group to determine if usual care was deemed necessary. In addition, the duration of neck pain was not collected at the initial examination to determine the chronicity of pain, and thus the study might have included a mix of subacute and chronic population, and the outcome could be different for these populations in the first place. However, all participants had a duration of more than two weeks of neck pain.

Another limitation of our study was that the small sample size. A total of 43 were enrolled in the study but due to attrition only 38 subjects completed the study. Post hoc power analysis revealed that the power based on this sample was 0.73. It is possible that we were not able to identify additional significant differences in outcome measures between the two study groups due to the small sample size. Thus, we recommend conducting further studies with a larger sample size and longer follow-up time to enhance the generalizability of the study's findings. Lastly, caution should be taken when interpreting study's findings, since it is not known whether the added attention and time spent with the therapist, as well as patient's attitude and expectation toward rehabilitation had an effect on the outcomes or not, since they were not evaluated. We recommend future study to investigate the potential association between patient's cognitive factors and the nature of administered procedures as patient's expectation might play a great role in the improvement noted in both groups (Kjellman et al., 2002).

5. Conclusion

The results of this study showed that both study groups improved significantly in all outcome measures including pain and disability, however, adding stretching to the standard procedure did not produce any additional improvement to pain and disability levels. Nevertheless, the combined procedures (cervical mobilization, ACROM exercise, and stretching procedures) might be more efficacious than standard procedure (cervical mobilization and ACROM exercises) at improving active cervical extension, lateral flexion and right rotation in adults with non-specific mechanical neck pain. It should be noted that findings are for short-term outcomes only, and therefore, future studies with a larger sample size and a longer follow-up period are needed to further examine these findings.

5.1. Adverse events

No adverse events or harms related to the provided interventions were reported during the period of the study.

6. Clinical relevance

- Incorporating stretching techniques to cervical mobilization and active cervical range of motion (ACROM) exercises might be more efficacious than cervical mobilization and ACROM exercises alone at improving ACROM in adults with non-specific mechanical neck pain (NSMNP).
- Adding stretching to mobilization and ACROM exercises, however, may not produce any additional improvement to pain and disability outcomes in adults with NSMNP.

Declaration of competing interest

The authors have no conflict of interest. This publication is an academic requirement of the author's institution.

CRediT authorship contribution statement

Saad Alfawaz: Data curation, Writing - review & editing, Conceptualization. **Everett Lohman:** Conceptualization, Project administration, Data curation, Resources, Supervision, Visualization, Validation, Writing - original draft, Writing - review & editing. **Mansoor Alameri:** Conceptualization, Data curation, Writing - original draft, Visualization, Validation, Writing - review & editing. **Noha Daher:** Supervision, Data curation, Formal analysis, Visualization, Validation, Writing - original draft, Writing - review & editing. **Hatem Jaber:** Writing - original draft, Conceptualization, Supervision, Data curation, Formal analysis, Visualization, Validation, Writing - review & editing.

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Appendix A. Supplementary data

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