The effect of manual therapy with augmentative exercises for neck pain: a randomised clinical trial

Shannon Bravo Petersen¹, Chad Cook², Megan Donaldson³, Amy Hassen³, Alyson Ellis⁴, Ken Learman⁵

¹Des Moines University, Des Moines, IA, USA, ²Duke University, Durham, NC, USA, ³Walsh University, North Canton, OH, USA, ⁴Texas Physical Therapy Specialists, New Braunfels, TX, USA, ⁵Youngstown State University, Youngstown, OH, USA

Objectives: To compare the effect of manual therapy (MT) and an augmentative exercise programme (AEP) versus MT and general neck range of motion (ROM) on functional outcomes for patients with neck pain. A secondary objective was to examine changes in self-report measures and quantitative sensory testing (QST) following MT and AEP.

Methods: This was a randomised clinical trial. Seventy-two patients with neck pain were recruited. All patients received a single session of MT. Patients were randomly assigned to MT+AEP or MT+ROM. Clinical self-report outcome measures for disability and pain, and QST measures (pain and vibration thresholds) were collected at baseline, post MT treatment, at ~48hours, and at ~96hours. Repeated measures ANOVA and MANOVA were used to analyse within and between-group effects for clinical and QST measures.

Results: There were no between-group differences for disability, pain and QST measures. There was, however, a significant difference between groups for Global Rating of Change (GROC) scores ($P=0.037$). Patients in both groups showed improvements in pain, disability and trapezius pressure-pain threshold (PPT) (all $P<0.001$).

Discussion: Augmentative exercise programme does not significantly improve disability, pain or QST measures in patients with chronic neck pain although it may enhance their GROC scores. Over a 96-hour period, patients benefitted from MT plus exercise whether the exercise was general or specific.

Keywords: Central nervous system sensitisation, Exercise, Manual therapy, Neck pain, Self-report, Sensory testing, Spinal manipulation

Introduction

Manual therapy (MT) has been advocated for the treatment of mechanical neck pain with and without the use of supplemental neck exercises to improve patient outcomes.^{1–4} Mechanisms of action for pain relief associated with MT have been hypothesised to include both biomechanical^{3,4} and neurophysiological processes.^{5–10} Neurophysiological responses have been objectified using pain scales^{2,3,10–12} and quantitative sensory testing (QST) including pressure-pain threshold (PPT) and vibratory threshold.^{7,8} Although disability outcomes after manipulation or following exercise have been found to be similar,² there may be additional benefits in combining these interventions.¹ General home exercise programmes have been recommended in order to reduce pain and disability in

patients with neck pain; however, home exercises specifically prescribed to augment the MT techniques provided have not been examined.² The ability of specific follow-up exercises to influence disability and the hypothesised neurophysiological mechanisms following MT intervention is unknown.

Quantitative sensory testing impairment may be relevant even in patients without radicular symptoms. For example, vibration threshold can be impaired distally in non-radiculopathic conditions;¹³ however, changes distally with treatment have not yet been established. Objective changes have been reported previously in patients with subclinical neck pain.^{14–17} Impairments in cervical range of motion (ROM), kinaesthesia, cervical muscle endurance and cerebellar inhibition have been found in this population, yet changes in disability and QST measures following MT and exercise have not been reported.^{14–17} Evidence^{18,19} suggests that only short-term neurophysiological benefits

Correspondence to: Shannon Bravo Petersen, Des Moines University, 3200 Grand Avenue, Des Moines, IA 50325, USA. Email: shannon.petersen@dmu.edu.

result from a single session of MT provided without follow-up intervention. From a temporal perspective, neurophysiological effects of thrust manipulation have been found to be short lasting (30 minutes to 5 hours) and demonstrated to carry over when applied without exercise.¹² Similar results were found in a review of studies using only non-thrust manipulation.¹⁹ Both reviews^{18,19} suggested that MT does not appear to provide measurable lasting neurophysiological benefits when it is administered alone. Consequently, there may be other mechanisms that function as a catalyst for the carry-over benefit from MT. One such mechanism, exercise, has been shown to enhance the long-term effects of MT in the cervical²⁰ and lumbar spines.²¹ Many clinical research studies, in which the primary intervention was thrust and/or non-thrust manipulation, have also included concurrent exercise regimens.^{22–25} Since the treatment approach in these studies was multi-modal, the concurrent regimens may have *prolonged* the benefits from the MT. Despite this finding, the best type of exercise to prescribe in conjunction with MT has not been clearly established.

The literature does support the use of active exercise to supplement thrust and non-thrust MT techniques.^{1,2} However, the role of specific, prescribed follow-up exercises has yet to be examined in regards to their influence on or ability to prolong the hypothesised neurophysiological influences of an MT intervention. While general neck ROM exercises may be prescribed in conjunction with manual intervention,^{1,2} we propose an augmentative exercise programme (AEP), which is specifically designed to influence the patient's specific impairment that was identified during clinical examination. The goal of an AEP is to enhance the effects of MT intervention. For example, if patients received cervical left lateral flexion mobilisation as their MT intervention, they would perform a left lateral flexion active exercise while using their hand or a towel as a fulcrum over the painful region. It is unknown whether or not a programme of MT intervention combined with a specific AEP designed to enhance the effects of the MT and move into the patient's specific restriction enhances outcomes when compared to MT combined with general cervical ROM exercises. Therefore, the objective of this study was to determine if, after a single session of MT, a specific exercise programme compared to general cervical ROM results in an enhancement of the MT-induced neurophysiological changes and functional outcomes in patients with mechanical neck pain.

Methods

Design

The study was a randomised clinical trial approved by three University Institutional Review Boards and was registered at clinicaltrials.gov (NCT01750736). Treating therapists were not blinded to group allocation but were blinded to the results of the outcomes. Outcomes assessors were blinded to group allocation. Prior to involvement in the study, the investigators participated in standardised

training regarding the parameters of the study. The investigators were five physical therapists, including four Fellows in the American Academy of Orthopaedic Manual Physical Therapists, and five graduate assistants that served as outcomes assessors.

Participants

An *a priori* sample size calculation using a proposed effect size of 0.40, a desired power of 80%, and an alpha of 0.05 determined that 60 patients would be needed to find statistical significance. Assuming a potential 20% dropout rate, we recruited 72 participants. All patients, recruited by word of mouth and through direct advertisement between October 2012 and May 2013, provided written informed consent. They also completed a patient history and general medical questionnaire to help determine eligibility status for the study. Inclusion requirements were individuals 18 years of age or older with neck pain of any duration and mobility deficits of the neck. Patients were excluded if 'red flags' were noted in the patient's examination for serious spinal pathology (i.e. tumour, osteoporosis, infection or fracture, etc). Exclusion criteria also included use of blood thinners, a whiplash injury within the past 6 weeks, evidence of central nervous system involvement [hyperreflexia, (+) Babinski, (+) Hoffmann's], presence of signs consistent with nerve root compression (decreased dermatomal sensation, myotomal weakness, pathological deep tendon reflexes). Finally, patients were excluded if they reported neck or thoracic spine surgery, were on worker's compensation, had pending litigation for their neck pain or had insufficient English language skills to complete questionnaires.

Study procedures

During the initial visit, an investigator performed a comprehensive cervical spine examination designed to identify appropriateness of MT approach and to determine the direction of movement restriction and location of the neck physical impairments. Specifically, active cervical ROM, passive accessory intervertebral motion testing and passive physiological intervertebral motion testing were used to localise the direction of limitation and the location of symptoms and/or segmental hypomobility. The investigator also identified the location of trigger/tender point with a skin pencil for the application of PPT testing to follow.

Measures: self-report

After the physical examination, a variety of outcome measures were used to examine recovery through multiple constructs. The Neck Disability Index (NDI)²⁶ was the primary outcome of interest and the Numeric Pain Rating Scale (NPRS) was also used to assess pain impairment.²⁷ Several other self-reported outcomes measures were used to describe the patients' health status. The Tampa Scale for Kinesiophobia (TSK),²⁸ to measure fear of movement or re-injury was captured at baseline, as was the

Leeds Assessment of Neuropathic Symptoms and Signs (LANSS).²⁹ The LANSS, used to distinguish symptoms and signs of neuropathic origin from nociceptive pain, was administered since we also planned objective QST measures.

Measures: quantitative sensory testing

Two forms of QST were used as secondary outcome measures in this study, PPT and vibratory threshold (Vib). Pressure-pain threshold was measured using an algometer to apply pressure to a standardised area of the upper trapezius (TrPPT) and adductor pollicis (ThPPT) of the affected side. The area of the upper trapezius was determined by identification of an active trigger or tender point (the point that pressure either reproduced their chief complaint, caused referred pain, or was tender to the touch). Patients were told that a gradual pressure would be applied and were shown the device. They were instructed to indicate the point in time when they perceived the pressure as pain. The amount of force registered on the algometer (Baseline Push/Pull Force Gauge, Fabrication Enterprises Inc., White Plains, NY, USA), was recorded. The vibratory measure utilised a Bio-thesiometer (Bio-Medical Instrument Co., Newbury, OH, USA) over the interphalangeal joint of the thumb (ThVib) and acromioclavicular joint (ACVib), on the side of the neck pain. The vibratory intensity was gradually increased until the patient first detected the sensation of vibration. An average of two trials of each QST measured 1 minute apart represented the final measure for that time point.³⁰ This technique has been found to have excellent reliability over the trapezius with inter-rater intraclass correlation coefficient [$ICC_{(2,1)}$] at 0.96 with a 95% confidence interval (CI) of (0.91, 0.98) and intra-rater reliability of 0.96 (0.91, 0.98).³⁰

Manual therapy interventions

Following baseline assessment, a single session of MT was provided. Examination findings specific to pain and ROM deficits served to guide the investigator in selection of specific manual interventions for each patient; this included active and passive ROM assessment as well as passive intervertebral mobility assessment. Interventions selected were directed towards both the direction of motion impairment and intervertebral segment found to be symptomatic. Select interventions of thrust or non-thrust manipulation to the cervical spine were performed pragmatically to address the individual patient's specific motion limitations and/or concordant pain. The non-thrust manipulation was performed as an oscillation with amplitude determined by the investigator, while the thrust manipulation was a high-velocity low-amplitude movement (Fig. 1). This approach was similar to that used by Leaver *et al.*³¹ where the treating clinician chose the thrust or non-thrust manipulation based on clinical judgement.

(Continued)

(A-B) Manual therapy interventions. (A) Non-thrust manipulation; (B) Thrust manipulation for lateral flexion and rotation; (C-F) Augmentative cervical exercises.

A review from Gross *et al.*³² found similar results for pain, function and patient satisfaction whether thrust or non-thrust manipulation was provided to patients with neck pain.³² Since the augmentative exercises prescribed, by definition, were performed into the same direction and at the same spinal level as the MT intervention based on individual patient findings, both interventions were unique to each patient. The MT interventions were performed *only* on the first visit.

Outcomes measures were captured following the MT session and comprised the NPRS and the QST. In addition, an assessment of overall well-being, the Global Rating of Change (GRoC) was included.³³ Following the post-intervention outcomes assessment, the treating investigator revealed the patient's group allocation and instructed the patient in the home exercise programme.

Randomization

A research assistant used a computer-based random number generator to create group assignments that were placed in envelopes numbered consecutively prior to patient enrolment. Contents of the envelope were concealed from the patient and investigator performing the MT intervention until after the MT intervention in order to reduce group allocation bias. Patients were assigned to one of two groups receiving either MT plus ROM exercises (MT+ROM) or MT plus AEP (MT+AEP).

ROM exercise intervention

General exercises performed by those in the MT+ROM group consisted of active cervical ROM in each direction: extension, flexion, rotation and side flexion. Patients were asked to complete 12 repetitions six times daily until the last follow-up session (4days).

Augmentative exercise intervention

The evaluating investigator chose augmentative exercises for each individual patient in the MT+AEP group. The AEP also incorporated active ROM that was localised to the involved segment (most painful and/or most restricted) using their hand and a towel. Additionally, the direction of the AEP was determined by the direction of neck motion that produced the patients' specific concordant pain and/or ROM restriction and was intended to target the painful or restricted segment of the neck (Fig. 1). The rationale for the AEP was to enhance the MT treatment approach that was chosen for each individual patient in both the specific direction of restriction and segment targetted. Patients were asked to complete 12 repetitions six times daily until the last follow-up session (4days).

At both the 2-day and 4-day follow-up sessions, the NDI, NPRS, QST, GRoC, were performed as before. In

Figure 1 (Continued)

Figure 1 (A-B) Manual therapy interventions. (A) Non-thrust manipulation; (B) Thrust manipulation for lateral flexion and rotation; (C-F) Augmentative cervical exercises.

addition, the Self-Report Activity Scale (SRAS) and the Rate of Recovery (RoR) were added. These outcomes were captured in subsequent visits for follow-up assessment and were designed to measure disability (NDI), report of pain (NPRS), change in well-being (GROC) and change in activity level (SRAS) since baseline. Rate of recovery was collected at the last data collection session. The RoR is a scale from 0 to 100%. The patient is asked to report how much improvement he/she has noticed during the course of care as a percentage score. This variable has been previously used in studies on low-back pain²⁵ and shoulder pain.³⁴

To measure HEP adherence, we used a novel measure that asked patients to rate their confidence on their ability to perform the home exercise interventions and asked patients to complete an exercise diary. Based on this diary, the clinician recorded the patient's efforts as: *Highly Compliant*, *Compliant*, *Not Compliant* or *Extremely Not*

Compliant. To reduce study bias, all follow-up measures, including QST values at 48 and 96 hours, were captured by a trained, blinded assessor who was not the treating clinician.

Data analysis

Data analyses were comprised descriptive statistics for continuous and categorical variables. Independent samples *t*-tests were used to analyse continuous variables (age, height, weight, body mass index, LANSS, TSK). Dichotomous and categorical variables (e.g., presence of a trigger point) were analysed using a Pearson chi-square (χ^2).

The normality of the distributions of each dependent variable cell within the analysis was plotted with histograms, normal distribution curves and Q-Q plots to assess a visual fit.³⁵ Furthermore, skewness and kurtosis for each

of the cells were assessed using Shapiro–Wilk analyses. Linearity was examined using bivariate scatter plots of observed residual values against the expected values.

The primary clinical outcome of interest, the NDI, was analysed with a repeated measures analysis of variance (RM ANOVA) at three time points, baseline, 2-day and 4-day follow-up. The secondary outcomes of interest, the NPRS and QST variables, were examined in one, repeated measures MANOVA at four time points, baseline, post-intervention, 2-day and 4-day follow-up. Additional outcomes of interest, the GRoC, SRAS and RoR, were examined with independent samples *t*-tests. Home exercise programme adherence was examined by χ^2 . All statistical analyses were performed in SPSS 20.0 (IBM Corp, Armonk, New York, NY, USA).

Results

Seventy-two patients were recruited (Fig. 2). One patient declined to participate, one was lost to follow up and one

was involved in a motor vehicle accident after the initial visit and was removed from the study. Table 1 outlines the descriptive characteristics of the patients for both exercise groups.

There was neither statistically significant difference between the MT+AEP and MT+ROM programmes for the primary outcome of disability ($F=0.01$, $P=0.914$) nor was there time*group interaction ($F=0.87$, $P=0.35$). There was a main effect for time ($F=62.06$, $P<0.001$). Pairwise comparisons suggested that differences existed between each time point (Fig. 3).

The RM MANOVA revealed neither statistically significant differences between groups for the secondary QST outcomes of TrPPT, ThPPT, ACVib and ThVib nor pain (NPRS) with ($F=1.23$, $P=0.31$). The analysis did reveal a main effect for time ($F=8.34$, $P<0.001$) but no group*time interaction ($F=1.25$, $P=0.27$). The univariate analysis showed the effect for time existed only for NPRS ($F=17.6$, $P<0.001$) and TrPPT ($F=8.59$, $P<0.001$). All

Figure 2 Flow diagram of patient recruitment and retention.

Table 1 Descriptive characteristics of the patients receiving manual therapy grouped by all, manual therapy+augmentative exercise programme (MT+AEP), and manual therapy+range of motion exercises (MT+ROM) patients (N=69). Leeds Assessment of Neuropathic Symptoms and Signs (LANSS), Neck disability index (NDI), Numeric pain rating scale (NPRS), Tampa Scale for Kinesiophobia (TSK), and Pressure-pain threshold (PPT).

Variable	MT+AEP group patients, mean (SD)/frequency N=34	MT+ROM group patients, mean (SD)/frequency, N=35	P-value
Age (years)	34.3 (16.4)	33.5 (13.5)	0.83
Gender	13 = male 21 = female	15 = male 20 = female	0.70
Race	34 = White 0 = Black 0 = Hispanic 0 = Asian 0 = Other	34 = White 0 = Black 0 = Hispanic 1 = Asian 0 = Other	0.32
Height	66.1 (4.3)	66.1 (4.2)	1.00
Weight	151.4 (31.4)	160.2 (41.2)	0.32
Body Mass Index	24.3 (4.1)	25.4 (4.3)	0.25
Duration of symptoms (weeks)	75.0 (89.8)	79.2 (93.4)	0.85
Baseline LANSS	2.0 (3.0)	1.3 (2.9)	0.30
Trigger points	15 = active 18 = latent 1 = missing	11 = active 24 = latent 0 = missing	0.29
Technique received	11 = thrust 23 = non-thrust	7 = thrust 28 = non-thrust	0.24
Baseline NDI (0-50)	12.1 (4.6)	11.4 (8.3)	0.67
Baseline NPRS	3.1 (1.6)	2.6 (1.7)	0.28
Baseline TSK	30.9 (6.3)	31.8 (5.1)	0.54
Baseline Trap PPT	5.2 (3.6)	7.6 (8.3)	0.12
Baseline thumb PPT	7.9 (6.4)	10.1 (10.1)	0.28
Baseline AC vibration	10.3 (5.7)	9.1 (4.9)	0.33
Baseline Thumb vibration	4.4 (1.8)	3.5 (1.5)	0.02

Figure 3 Pairwise comparisons of pain and disability.

other variables (ThPT, ACVib and ThVIB) were not significant at $P > 0.05$. Pairwise comparisons revealed that for the NPRS, a large and significant improvement occurred immediately following the MT treatment with additional progression to time point 4 and that for TrPPT, there was gradual progression from time point 1 to time point 4 with significant differences between time points 1 and 4, and 2 and 4 (Figs. 3 and 4). Table 2 provides raw mean values with standard deviations for pain, disability and QST variables for each time point, baseline, post-intervention, day-2 and day-4 follow-up. It also provides within-group change values for follow-up testing sessions compared with baseline scores with 95% CIs. Table 2 also provides between-group differences in those change scores with 95% confidence intervals. Table 2 provides within-group and between-group effect sizes for intervention broken down by treatment type, MT and exercise group.

The t -tests revealed significant between-group differences for self-report GROC scores ($T = 2.82$, $P = 0.006$), but not for either the RoR ($T = 1.41$, $P = 0.16$) or SRAS ($T = 1.84$, $P = 0.07$) scores. There were no between-group differences in adherence with the home exercise programme, as examined by χ^2 ($P = 0.88$) (Table 3).

Discussion

The purpose of this study was to determine if specificity of prescribed exercises for patients with neck pain following a single session of MT resulted in enhanced changes associated with the MT intervention. Changes in

Figure 4 Pairwise comparisons of quantitative sensory testing (QST) measures.

self-report measures and QST were examined. We found no significant differences between intervention groups for the primary outcome of NDI or the secondary self-reported outcomes or QST measures. Within-group improvements were seen in both the MT+AEP and MT+ROM groups. Only one of the secondary outcomes, the GRoC, yielded significant between-groups difference.

Although change in NDI did not differ significantly between groups, patients in both groups improved. The minimal detectable change (MDC) and minimal clinically important difference (MCID) for the NDI have been previously reported as 8.4 points and 3.5 points, respectively, when examined over a 3- to 5-month period.³⁶ When examined over an average of 2.5 days, the NDI was found to have a slightly higher MDC of 19.6% (9.8 points) and MCID of 19% (9.5 points).³⁷ In the current study, we managed patients over a 96-hour period. Patients in both groups attained the MCID, as determined by Jorritsma *et al.*³⁶ by the final follow-up session but failed to achieve the MDC, as defined by these studies. This is possibly a reflection of the low initial disability levels in these patients.

Interestingly, the GRoC was the only self-report measure resulting in a statistically significant difference

between groups. Augmentative exercises were designed to supplement the MT intervention by working into the movement restriction of the patient, with focus at the level of impairment. We hypothesise that these procedures may have felt more 'specific' for the patients who were allocated this form of the HEP. Since the GRoC is a unique measure that is influenced by multiple factors, it is possible that this perceived element of connectivity with the HEP and their unique impairment influenced the patients' interpretation of their improvement. Our finding is consistent with a previous study using a self-mobilisation approach within a HEP prescription in which improvements in patient well-being were found.³⁸

We found no significant between-group differences for any of the QST measures following the MT treatment. Since our patients did not demonstrate LANSS's scores consistent with neuropathic pain, the likelihood of distal involvement was minimised when compared with local nociceptive tenderness.^{13, 39}

Immediate changes have been previously reported in patients with chronic neck pain following a single session of MT.¹¹ Despite the chronicity of symptoms in the current study, changes in pain and disability continued

Table 2 Manual therapy+augmentative exercise programme (MT+AEP) group (Aug) and manual therapy+range of motion exercises (MT+ROM) group (non) outcomes over time: Numeric pain rating scale (NPRS), neck disability index (NDI), pressure-pain threshold (PPT), and vibration.

	Baseline		Post-intervention		2-days post		4-days post	
	Mean ($\pm$ SD)		Mean ($\pm$ SD)		Mean ($\pm$ SD)		Mean ($\pm$ SD)	
	Aug	Non	Aug	Non	Aug	Non	Aug	Non
NPRS (0–10)	3.1 (1.6)	2.6 (1.7)	2.0 (1.9)	2.0 (1.8)	2.0 (2.1)	2.2 (2.0)	1.7 (2.0)	1.7 (1.9)
Within-group change score from baseline			–1.1 (–1.5, –0.7)	–0.6 (–1.0, –0.2)	–1.1 (–1.6, –0.5)	–0.5 (–1.0, –0.1)	–1.3 (–1.8, –0.8)	–0.9 (–1.5, –0.4)
Between-group difference in change score				0.5 (–0.1, 1.0)		0.6 (–0.2, 1.3)		0.4 (–0.3, 1.2)
NDI (0–50)	12.1 (4.6)	11.4 (8.3)						
Within-group change score from baseline					8.9 (6.4)	9.3 (8.6)	7.3 (6.5)	7.6 (8.4)
Between-group difference in change score					–3.3 (–5.0, –1.5)	–2.1 (–3.4, –0.8)	–4.8 (–6.7, –2.9)	–3.8 (–5.0, –2.6)
PPT Trap (ft*lbs)	5.2 (3.6)	7.6 (8.5)	5.8 (4.3)	7.2 (7.3)	6.7 (5.9)	8.0 (8.8)	7.2 (6.0)	9.0 (10.1)
Within-group change score from baseline			0.6 (0.1, 1.2)	–0.4 (–1.2, 0.3)	1.5 (0.2, 2.9)	0.3 (0.8, 1.5)	2.0 (0.6, 3.4)	1.4 (0.3, 2.5)
Between-group difference in change score				1.1 (0.1, 2.0)		1.2 (–0.6, 3.0)		0.6 (–1.2, 2.3)
PPT Thumb (ft*lbs)	7.9 (6.4)	10.1 (10.1)	7.1 (6.0)	8.8 (8.0)	7.7 (7.8)	9.6 (10.3)	7.8 (6.6)	9.3 (9.8)
Within-group change score from baseline			–0.8 (–1.4, –0.2)	–1.3 (–2.5, –0.2)	–0.2 (–1.3, 0.9)	–0.5 (–1.6, 0.5)	–0.1 (–1.4, 1.1)	–0.8 (–1.8, 0.3)
Between-group difference in change score				0.6 (–0.8, 1.9)		0.3 (–1.2, 1.85)		0.6 (–0.9, 2.2)
Vibration A/C (V)	10.3 (5.7)	9.1 (4.9)	9.5 (5.2)	8.2 (4.1)	8.9 (4.7)	9.1 (3.0)	9.3 (4.9)	8.5 (3.5)
Within-group change score from baseline			–0.8 (–1.5, –0.0)	–0.8 (–1.6, –0.1)	–1.4, –2.5, –0.3)	0.0 (–1.1, 1.2)	–1.0 (–2.4, 0.3)	–0.5 (–1.5, 0.5)
Between-group difference in change score				0.1 (–1.0, 1.1)		1.4 (0.1, 3.0)		0.5 (–1.2, 2.1)
Vibration thumb (V)	4.4 (1.8)	3.5 (1.5)	4.4 (1.8)	3.3 (1.4)	4.0 (1.6)	3.3 (1.3)	4.0 (1.6)	3.6 (1.4)
Within-group change score from baseline			0.0 (–0.3, 0.3)	–0.2 (–0.5, 0.1)	–0.4 (–0.8, 0.0)	–0.2 (–0.5, 0.1)	–0.4 (–0.8, –0.0)	0.1 (–0.3, 0.6)
Between-group difference in change score				0.2 (–0.2, 0.6)		0.3 (–0.2, 0.8)		0.6 (0.0, 1.2)

Table 3 Between-group differences for outcomes of interest.

Variable	MT+AEP group patients, mean (SD)/frequency N=34	MT+ROM group patients mean (SD)/frequency N=35	P-value
Adherence	26 = very adherent 7 = adherent 1 = not adherent	25 = very adherent 9 = adherent 1 = not adherent	0.88
GROC	3.6 (2.6)	1.9 (2.5)	*0.006
RoR	55.0 (33.2)	43.6 (34.6)	0.16
SRAS	1.4 (1.9)	0.7 (1.45)	0.07

GROC: Global Rating of Change; RoR: rate of recovery (%); SRAS: self-reported activity scale.

to improve over the 96-hour period of time examined. Because no longer-term follow-up was performed, it is not known how long this improvement would continue. In the previous studies showing immediate improvements following MT, these benefits lasted varying degrees of time. Improvements have ranged from 5 minutes to 5 hours, and up to 24 hours in one case when applied without concurrent interventions.^{10, 11, 18, 19} Although still relatively short-term, results seen with the current study appear to be longer-lasting than previously reported; some outcomes were still improving 96 hours post-intervention. This duration may be clinically relevant when considering time-frame between physical therapy visits and carry-over between sessions. Short-term improvements may be an important factor in predicting long-term outcomes. Cook *et al.*⁴⁰ found improvements in both within-session and between-session measures can be useful in predicting treatment success in patients with neck pain. Gustavsson *et al.*⁴¹ examined a self-management intervention for patients with persistent neck pain and found that short-term outcomes for disability, pain and self-efficacy were associated with long-term improvements. We hypothesise that these longer-lasting results we observed in comparison to previous studies^{10, 11, 18, 19} may be due to the type of augmentative interventions used in combination with the MT.

Limitations

There were several limitations to this study. The sample size for this study, although based on power analysis, was still relatively small, which could potentially make the study vulnerable to imbalances across groups. Addition of a third intervention group who received no HEP would have aided in truly determining the value associated with the HEP. Intra- and inter-rater reliability of the QST measures were not assessed in this study. The impact of neck pain chronicity on QST testing is unknown at this time. Additionally, our patients' baseline data revealed low initial pain and disability scores, which could limit the significant improvement or influence on outcomes compared to those with more acute and/or higher pain or disability scores through a floor effect. Many studies have limited inclusion to patients demonstrating pain scores of at least 2/10

or NDI scores of at least 10/50 (20%). A cursory assessment of data stratified by initial pain scores would suggest that little change would occur in overall effect sizes. It is unclear whether these low starting scores could account for lack of variability seen between-groups over time; and whether greater change in time would have occurred in patients with higher degrees of pain. It should be pointed out, however, that despite the low levels of pain and disability, and the relative chronicity of this sample, clinically meaningful improvements were noted with pain and disability. This sample's average pain score improvement of 57% exceeded the 30% change observed by Ferrar *et al.*⁴² suggesting that patients with mechanical neck pain may be managed effectively with a simple MT and exercise intervention. Generalisability of the results may be impacted by the fact that for this study, the MT was only administered during a single session. In clinical practice, patients may be seen for manual intervention over a longer course.

Conclusion

The results of this study suggest improvements in neck disability and pain do not differ, for at least a 96-hour period, between patients performing general exercises and those performing an AEP following MT. Similarly, changes in QST measures do not appear to differ based on the specificity of home programme prescribed. The results of this study do suggest, however, that for patients with lower levels of neck pain and disability, short-term self-reported global improvement is higher in those individuals receiving an AEP in addition to manual interventions. Furthermore, regardless of the exercise programme assigned, patients showed continued benefit with the combined intervention over a 96-hour period.

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Disclaimer Statements

Contributors

Petersen: inception of idea, data collection, attaining funding, final write-up/approval of the manuscript. Cook: inception of idea, data collection, data analysis/interpretation; attaining funding, final write-up/approval of the manuscript. Learman: data collection, data analysis/interpretation; attaining funding, final write-up/approval of the manuscript. Donaldson: inception of idea, data collection, attaining funding, final write-up/approval of the manuscript. Ellis: data collection, data input, literature review/reference organization; final write-up/approval of manuscript. Hassen: data collection, writing of final manuscript/approval of final manuscript.

Conflicts of interest The authors have no conflict of interest associated with this manuscript.

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