Immediate Effects of Active Versus Passive Scapular Correction on Pain and Pressure Pain Threshold in Patients With Chronic Neck Pain

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Abstract

Objective: The purpose of this study was to investigate the effect of active vs passive scapular correction on pain and pressure pain threshold at the most symptomatic cervical segment in patients with chronic neck pain.
Methods: Twenty-three volunteers with chronic, idiopathic neck pain were recruited (age, 38.9 ± 14.4 years; sex [man/woman], 3/20; Neck Disability Index, 28.1% ± 9.9%). Subjects were randomly allocated to 2 groups: active scapular correction or passive scapular correction. Pressure pain threshold and pain intensity rated on a numerical rating scale during a posteroanterior glide over the most symptomatic cervical segment were measured before and immediately after the active or passive scapular intervention.
Results: Only the active scapular correction produced a reduction in pain (pre, 6.3 ± 1.2; post, 3.7 ± 2.4; $P < .05$) and increase in pressure pain threshold (pre, 8.7 ± 4.2 kg/cm^2; post, 10.1 ± 3.8 kg/cm^2; $P < .05$) at the most painful cervical segment.
Conclusions: An active scapular correction exercise resulted in an immediate reduction of pain and pressure pain sensitivity in patients with chronic neck pain and scapular dysfunction. (J Manipulative Physiol Ther 2014;37:660-666)
Key Indexing Terms: *Neck Pain; Exercise; Scapula; Intervention; Randomized Trial*

Clinical theory contends that aberrant scapular posture and associated changes in axioscapular muscle activity may contribute to or exacerbate painful neck disorders by adversely affecting mechanical stress on pain sensitive cervical structures.[1] For instance, it has been suggested that a depressed scapula may lead to thoracic outlet syndrome with stress on muscle tissue (eg, overstretching of the upper trapezius) and compression of the neurovascular bundle of the upper limb.[2] Consequently, scapular postural correction strategies have been advocated as a component of the intervention for patients with neck pain who display an alteration of scapular orientation.[3-5]

Correct scapular position at rest and during movement depends on appropriate coordination between axioscapular muscles such as the serratus anterior and all 3 divisions of the trapezius muscle.[3] A scapular postural correction exercise has been shown to be effective at altering the pattern of activity of the middle and lower fibers of the trapezius muscle in patients with neck pain to better reflect that displayed by healthy individuals.[6] However, most studies assessing scapular orientation and scapular control

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Paper submitted December 4, 2012; in revised form July 21, 2014; accepted August 21, 2014.
0161-4754
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http://dx.doi.org/10.1016/j.jmpt.2014.08.007

with movement have been conducted in patients with shoulder pain and dysfunction.[7,8] Little is known about the consequence of altered scapular orientation on neck pain or the effect of axioscapular muscle exercise on neck pain symptoms.

The purpose of this study was to investigate the immediate effects of an active scapular correction exercise on pain and pressure pain thresholds (PPTs) over the most cervical symptomatic segment in patients with chronic neck pain and scapular dysfunction. The active intervention was compared with a passive scapular correction to evaluate the importance of the active component of scapular correction on neck symptoms.

Methods

Participants

Volunteers aged between 18 and 60 years with chronic idiopathic neck pain were invited to participate in the study. Recruitment was performed during the year 2012 by notices distributed in different universities and hospitals of Valencia (Spain). Data collection was performed at the University CEU Cardenal Herrera, Valencia, Spain. Besides presenting with a history of neck pain lasting 3 months or more over the last year, patients were required to have a score of greater than or equal to 5/50 on the Neck Disability Index (NDI), the minimal score required to reflect the presence of at least a mild neck pain disorder.[9] The Spanish validated version of NDI was used.[10] To justify the application of a scapula correction strategy, the presence of scapular dyskinesis was also required (for details see below). *Scapular dyskinesis* is a term used to refer to impairment of scapula position or movement.[11]

Subjects were excluded if they had previous cervical spine or shoulder surgery, cervical radiculopathy, presence of a severe systemic disease (ie, diabetes), fibromyalgia, or other widespread musculoskeletal pain syndromes (ie, chronic fatigue syndrome) or had participated in an exercise program for the neck or scapular muscles in the 6 months preceding the study. Patients were also advised to avoid consumption of stimulants (caffeine and nicotine) or analgesic drugs for at least 8 hours before the study.

The study was approved by the Ethics and Research Committee of the University CEU Cardenal Herrera, Valencia, Spain. Procedures were conducted according to the Declaration of Helsinki. All subjects provided consent to participate in this study.

Study Design

Patients were randomly allocated to 2 groups using a computer-generated sequence of numbers by an independent researcher. In the active group, the patients were instructed to perform an active exercise to correct their scapula position to a neutral position, whereas the scapula was passively positioned in a neutral position in the other group. Because the 2 interventions (active/passive) involved therapist facilitation, the patients were blinded to the intervention type. Surface electromyography (EMG) was detected from the lower trapezius during both interventions (active/passive), and the absence of muscle activity during the passive correction was confirmed. A second investigator, blinded to the intervention type, performed the outcome measures before and immediately after scapula correction. This included PPTs over the most symptomatic cervical segment and over the tibialis anterior muscle ipsilateral to the side of intervention. Moreover, pain intensity was rated on a numerical rating scale (NRS) by the patient as the investigator performed a posteroanterior glide over the most symptomatic cervical segment (same location as the PPT measurement).[12]

Procedure

Volunteers for the study were firstly screened to confirm the presence of scapular dyskinesis. This assessment was performed by a physical therapist with 10 years of experience of assessing patients with neck pain for scapular dysfunction. In addition, the same therapist determined the most symptomatic cervical segment on manual examination of the cervical spine and pain intensity on an NRS during a grade IV unilateral posteroanterior glide on this most painful segment was determined. This cervical segment was then marked for the PPT assessment.

Pressure pain threshold at the same site was then measured by another investigator blinded to the group allocation of each patient (active or passive). Upon completion of the intervention and after a rest period of 60 seconds, measurement of pain intensity during a grade IV unilateral posteroanterior glide on the same painful segment and PPT measures was repeated.

Assessment of Scapular Dyskinesis. Assessment of scapular dyskinesis was performed using the Scapular Dyskinesis Test.[13] This test has shown good reliability and validity[14] for the identification of scapular dyskinesis. Briefly, each patient was required to do 5 repetitions of active shoulder flexion and abduction, bilaterally, while holding a weight with their hands (1.4 kg for patients weighting <68.1 kg and 2.3 kg for patients weighing >68.1 kg). The patients were asked to elevate their upper limbs as far as possible while keeping their thumbs pointing upwards and then return to neutral. Each cycle of upper limb elevation and return to the start position lasted 6 seconds (3 seconds per phase). A therapist was positioned ~2 m behind the patient to evaluate the presence of aberrant mobility of the scapula. The presence of scapular dyskinesis was confirmed by visual observation of any of the following movement anomalies:

winging (prominence of the medial or inferior border of the scapula) or dysrhythmia (premature or excessive elevation or protraction, stuttering motion of scapula during upper limb elevation or returning phase, or inferior rotation of the scapula during returning phase).

The intervention and measurements of pain and PPT were performed on the side of scapular dyskinesis. In the event that the patient had bilateral scapular dyskinesis, the therapist selected the side with greatest impairment (evaluated visually).

Assessment of Symptomatic Cervical Articular Dysfunction. Manual examination consisted of passive accessory intervertebral movements performed in prone with the cervical spine in a neutral position. The examiner applied a progressive unilateral posteroanterior pressure over the cervical articular pillars, on the side of scapula dysfunction, aiming to reproduce a patient symptomatic response. Each level was tested a maximum of 2 times to avoid worsening of symptoms. A segment was considered asymptomatic if it did not reproduce symptoms with a firm pressure (grade IV mobilization). The *symptomatic segment* was defined as the location that reproduced the most pain. Once this segment was determined, the patients rated their pain intensity (NRS), which was documented. This examination approach has been shown to be reliable in assessing patients with neck pain and cervicogenic headache.[15]

Pressure Pain Threshold. Pressure pain threshold was measured with an analog algometer (Force Dial model FDK 20; Wagner Instruments, Riverside, CT) with a surface area at the round tip of 1 cm^2. The algometer probe tip was applied perpendicularly to the skin at a rate of 1 kg/cm^2 per second. To standardize the speed of application, the researcher responsible for this measurement practiced, 1 week before the study, increasing the pressure linearly to 5 kg/cm^2 over 5 seconds according to the method recommended by others.[16]

Pressure pain threshold was measured over the most symptomatic segment and the ipsilateral tibialis anterior muscle 3 times at each site with a 30-second rest period between each measurement. A familiarization phase preceded the formal measurements where participants were instructed on the procedure and the examiner practiced with them at a remote site (forearm). Subjects were instructed to indicate the moment when pressure changed to pain, which corresponds to the definition of the PPT. They were told repeatedly that recording the first sensation of pain was the aim and not tolerance to pressure. The same researcher performed the PPT measurements in all subjects and was blinded to group allocation of each patient.

The mean of the 3 trials were calculated for each point and used for further analysis. Pressure algometry is a valid and reliable method to measure PPT, with studies showing good repeatability of measurements on the neck muscles (intraclass correlation coefficient, 0.78-0.93).[17]

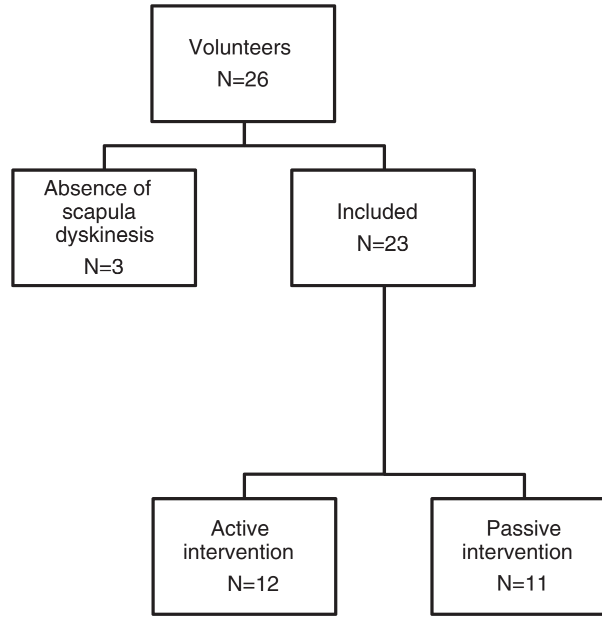

Fig 1. *Participant flow and retention.*

Electromyography. After skin preparation, 2 Ag/AgCl adhesive electrodes of 10-mm diameter with an interelectrode distance of 20 mm were placed over the lower trapezius at a position 2/3 along the line from the root of the spine of the scapula to the eighth thoracic vertebra, in the direction of the line between T8 and the acromion.[18] The reference electrode was placed over the spinous process of C7. Electromyographic signals were recorded with a 2-channel surface EMG amplifier (BioEMG; IACER, Venice, Italy).

Active Scapular Correction. The active intervention involved an adaptation of the conventional (grade 3) muscle test for the lower trapezius.[19] The intervention was performed in prone, with the arm resting on the plinth with the elbow in 45° of flexion. The examiner passively positioned the scapula in a neutral position on the posterior chest wall and asked the patient to hold the position for 10 seconds. This procedure was repeated for 10 repetitions with a 10-second rest interval between each contraction.

Passive Scapular Correction. The patient was positioned in the same starting position as for the active intervention. The examiner positioned the scapula passively to the neutral position and maintained the position for 10 seconds. This procedure was repeated for 10 repetitions with a 10-second rest interval between each repetition. The patients were asked to relax completely during this intervention, and the absence of visible EMG activity from the lower trapezius muscle confirmed the passive nature of the task.

Table 1. *Baseline Characteristics of the Sample*

Variable	Total (n = 23)	Active (n = 12)	Passive (n = 11)
Age (y)	38.9 ± 14.4	33.7 ± 12.5	44.6 ± 14.6
Sex (man/woman)	3/20	2/10	1/10
Weight (kg)	62.7 ± 11.2	63.5 ± 10.0	61.8 ± 12.8
Height (cm)	164.9 ± 9.2	165.5 ± 8.8	164.1 ± 9.9
NDI (%)	28.1 ± 9.9	25.5 ± 6.7	31.0 ± 12.1
Most symptomatic level			
C1/2	n = 6	n = 3	n = 3
C2/3	n = 8	n = 4	n = 4
C3/4	n = 6	n = 4	n = 2
C4/5	n = 2	n = 0	n = 2
C5/6	n = 1	n = 1	n = 0

Values are expressed as mean ± standard deviation.
NDI, Neck Disability Index.

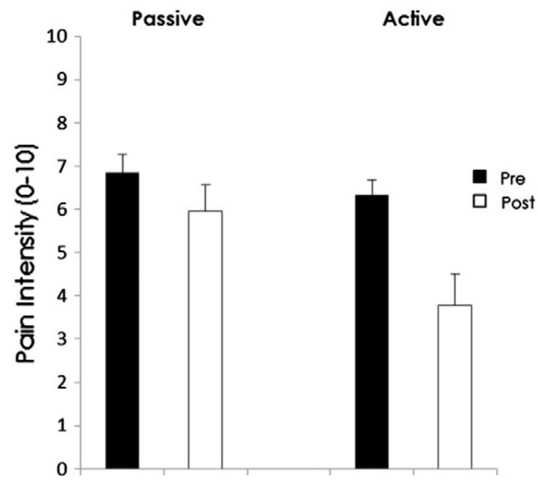

Fig 2. *Mean ± SE of the pain intensity rated by patients on a numerical rating scale (0-10) during a grade IV unilateral posteroanterior glide of the most symptomatic segment most both before and after intervention for patients performing active scapular exercise vs patients receiving passive correction of the scapula position.*

Statistical Analysis

Sample size was not determined a priori, but rather, a convenience sample of 26 subjects was included. This number was based on previous work, which compared the immediate effects of exercise and a control intervention, revealing significant differences between groups.[20]

Before statistical comparison, all data were tested for normal distribution by the Kolmogorov-Smirnov test, and normality was confirmed. A 2-way analysis of variance (ANOVA) was used to evaluate change in pain on posteroanterior mobilization of the most symptomatic segment of the cervical spine with group (active, passive) as the between-subjects factor and time (pre, post) as within-subject factors. Furthermore, 2-way ANOVAs were used to evaluate changes in PPT over the most symptomatic segment and tibialis anterior muscle with group (active, passive) as the between-subjects factor and time (pre, post) as within-subject factors.

Significant differences revealed by ANOVA were followed by post hoc Student-Newman-Keuls (SNK) pairwise comparisons. Results are reported as mean and SD in the text and SE in the figures. Statistical significance was set at $P < .05$.

Results

Participant flow is presented in Figure 1, and baseline characteristics of the active and passive intervention groups are presented in Table 1. There were no significant differences in baseline variables between the groups (all $P > .05$). No patients were lost after randomization. No adverse reactions were reported during either intervention.

A significant interaction between group and time was observed for the pain intensity rated on mobilization of the most symptomatic segment ($F = 5.8$; $P < .5$). A significant reduction in reported pain intensity on mobilization of the segment was observed for the active group (NRS: pre, 6.3 ± 1.2; post, 3.7 ± 2.4; SNK: $P < .001$) but not the passive group (NRS: pre, 6.8 ± 1.3; post, 5.9 ± 2.0) (Fig 2). Furthermore, a significant interaction between group and time was observed for the PPT measured over the most symptomatic segment ($F = 5.8$; $P < .05$). As seen for the reported pain intensity, a significant increase in PPT over the most symptomatic segment was only observed for the active group (SNK: $P < .05$) (Fig 3A). However, neither group showed a change in PPT over the tibialis anterior muscle post intervention (main effect for time: $F = 0.02$; $P = .87$; Fig 3B).

Discussion

This study evaluated the effect of active vs passive scapular correction on pain and PPT over the most symptomatic cervical segment in patients with chronic neck pain. In addition, PPT over a remote side (tibialis anterior) was evaluated to assess for possible systemic effects of the intervention. The results show that only the active intervention produces both a subjective and an objective improvement on pain at the most painful cervical segment in patients with chronic cervical pain. Pressure pain threshold over the tibialis anterior did not change with either intervention indicating that only a local hypoalgesic effect was induced with the active exercise.

Although the mechanisms underlying the immediate positive effect of the active exercise cannot be deduced from this study, the effect may be due to reciprocal inhibition of the elevator muscles (eg, upper trapezius, levator scapulae) after activation of the scapular depressors.

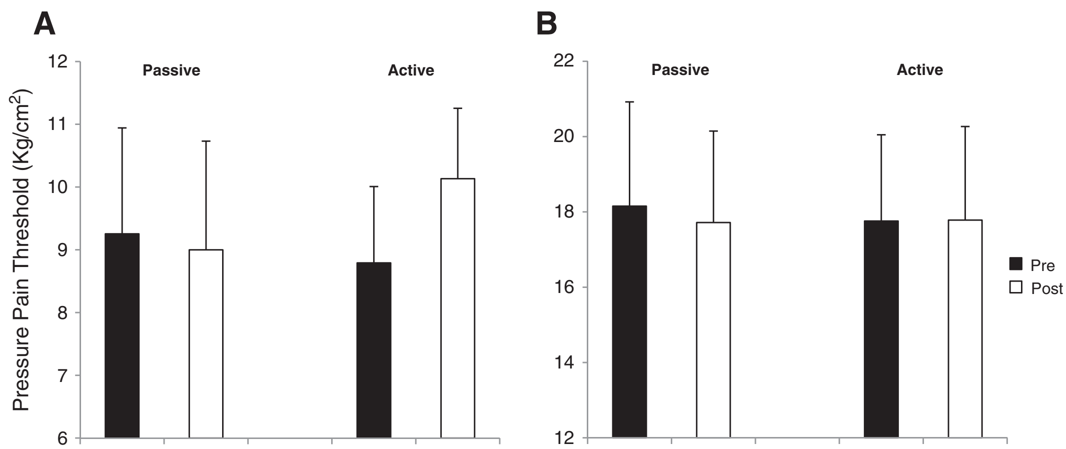

Fig 3. *A, Mean ± SE of the pressure pain threshold (PPT) detected over the most symptomatic segment both before and after intervention for patients performing active scapular exercise vs patients receiving passive correction of the scapula position. B, Mean ± SE of the pressure pain threshold (PPT) detected over the tibialis anterior muscle both before and after intervention for patients performing active scapular exercise vs patients receiving passive correction of the scapula position.*

Reciprocal inhibition is the physiological phenomenon in which there is an automatic inhibition of a muscle when its antagonist contracts, also known as Sherrington's law.[21] This is thought to be due to afferent impulses from agonist muscle spindles stimulating an inhibitory neuron in the spinal cord, causing inhibition of the activity in the alpha motor neuron to the antagonist muscle.[22] The observation that the passive intervention did not have an effect on pain or PPT locally over the cervical spine indicates that simply correcting the position of the scapula and perhaps optimizing the length of the elevator muscles are not sufficient for pain relief.

The cervical facet joint is a common source of pain in patients with neck pain, with an estimated prevalence that ranges from 25% to 66%.[23,24] Cervical spine joint mobilization (eg, oscillatory posteroanterior mobilization) is a manual technique commonly delivered by physiotherapists for treating patients with mechanical neck pain originating from facet joints. Manual therapy has been shown to elicit effects on pain perception measured with PPT, autonomic function, and motor function in subjects with neck pain.[25,26] The findings from the current study indicate that neck pain provoked from mobilization of a facet joint was immediately reduced with an active scapular correction strategy, without any intervention directly to the cervical spine. This observation should alert clinicians to the utility of the active exercise used in this study as an assessment to identify the contribution of axioscapular muscle dysfunction to the patient's neck pain condition. A positive effect of exercise on pain on mobilization of the cervical spine would suggest a benefit of incorporating scapular exercise as part of the treatment for relief of neck pain. The results of this study also suggest that pressure algometry is not required to identify a positive effect of the exercise clinically because pain rated on a grade IV unilateral posteroanterior glide of the most symptomatic segment also significantly reduced after exercise.

This study is the first to assess the immediate effects of active scapular exercise on PPT of the most painful cervical segment in patients with chronic neck pain. Previous studies have demonstrated positive effects on PPT and range of motion of the cervical spine (eg, rotation) with passive scapula correction (eg, elevation).[27-29] The influence of scapular position on cervical pain was also reported by Azevedo et al[30] who showed that healthy young subjects with a depressed scapula position had significantly reduced PPTs over the upper trapezius when compared with subjects with a normal scapula position.

The results of the current study suggest that only a local hypoalgesic effect was gained from the active exercise. This is in contrast to whole-body aerobic exercise, such as cycling and jogging, where immediate hypoalgesic responses to noxious stimuli applied to the fingers[31-34] and dental pulp[35,36] have been demonstrated. Such systemic effects of exercise were not observed for the active scapular exercise as evidenced by the lack of change in the PPT measured over the tibialis anterior muscle. Likely reasons for this lack of systemic effect include the short duration of exercise (10 repetitions of 10 seconds) and the low-load nature of the exercise. In contrast, aerobic exercise equating to 30 minutes at 75% of VO_2max (maximal oxygen uptake) was shown to modulate pain.[37]

The results from this study showed a reduction in neck pain immediately after scapular exercises. These findings suggest the potential value for incorporating scapular exercise in the management of patients with chronic neck pain for pain relief.

Limitations

Pressure pain threshold is used as an index to discriminate tenderness of musculoskeletal structures in different disorders. However, the specific tissues contributing to the change in threshold cannot be identified, as pressure algometry is not a diagnostic tool for differentiating soft tissue pathology from other conditions.[38] Moreover, pressure algometry does not determine the pain processing mechanisms underlying sensory changes in pain perception.[37] Although it is speculated that reduced activity of muscles overlying the facet joints (eg, upper trapezius and elevator scapulae) are responsible for the changes in PPT after the active scapular correction exercise, this cannot be confirmed from the present study.

Although pressure algometry may be considered as an objective measure, it is nevertheless subjective, as it is based on the patient's report of pain. A person's pain threshold is largely dependent on the instruction given and is related to the internal threshold criteria set by the subject.[39] Moreover, PPT may be influenced by the tester. However, in this study, the investigator performing the PPT measurements was blinded to the subject group to avoid such bias.

Although EMG of the lower trapezius was monitored in this study, the data were not recorded. Moreover, only the immediate effects of a scapular correction exercise were assessed in the current study, so future studies should investigate the duration of pain relief following this form of specific exercise.

There was a low representation of men in this study, and the sample size was not calculated a priori. Despite the small sample size, it was sufficient to show a significant change in pain and PPT immediately after the active intervention. The sample size is consistent with previous work, which showed significant pain relief immediately after active exercise vs a passive intervention in people with neck pain.[20] However, it should be acknowledged that a larger sample size may have affected the outcome of the study. This randomized trial compared the effect of an active vs passive intervention, which both involved therapist intervention. A control/placebo group was not included. A placebo group is recommended for future studies evaluating scapular interventions because a placebo effect may have partially accounted for treatment effects.[40]

Conclusion

For the group of subjects in this study, an active scapular correction exercise resulted in an immediate reduction of pain and pressure pain sensitivity over the most symptomatic cervical segment in patients with chronic neck pain and scapular dysfunction. No effect was observed for subjects who had passive correction of the scapula.

Funding Sources and Potential Conflicts Of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship

Concept development (provided idea for the research): E.L.L., M.D.A., O.C.Q., E.M.N., M.P.P., J.A.P.R., D.F.
Design (planned the methods to generate the results): E.L.L., M.D.A., O.C.Q., E.M.N., M.P.P., J.A.P.R., D.F.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): E.L.L., M.D.A., D.F.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): E.L.L., M.D.A., O.C.Q., E.M.N., M.P.P., J.A.P.R.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): E.L.L., M.D.A., O.C.Q., E.M.N., M.P.P., J.A.P.R.,D.F.
Literature search (performed the literature search): E.L.L., M.D.A., O.C.Q., E.M.N., M.P.P., J.A.P.R., D.F.
Writing (responsible for writing a substantive part of the manuscript): E.L.L., M.D.A, O.C.Q., E.M.N., M.P.P., J.A.P.R., D.F.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): E.L.L., M.D.A., D.F.

Practical Application

- An active scapular correction exercise, but not passive correction, induces an immediate reduction of pain and pressure pain sensitivity in patients with chronic neck pain.
- A local hypoalgesic effect was gained from the active exercise only.
- These results highlight the value of incorporating scapular exercise in the management of patients with neck pain for pain relief.

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