Specific Therapeutic Exercise of the Neck Induces Immediate Local Hypoalgesia

Shaun O’Leary,* Deborah Falla,*,† Paul W. Hodges,* Gwendolen Jull,* and Bill Vicenzino*
*Division of Physiotherapy, School of Health and Rehabilitation Sciences, University of Queensland, Brisbane, Australia.†Center for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Denmark.

Abstract: This study compared the effect of 2 specific cervical flexor muscle exercise protocols on immediate pain relief in the cervical spine of people with chronic neck pain. In addition, the study evaluated whether these exercise protocols elicited any systemic effects by studying sympathetic nervous system (SNS) function and pain at a location distant from the cervical spine. Participants were randomly allocated into either a cranio-cervical flexion (CCF) coordination exercise group (n = 24) or a cervical flexion (CF) endurance exercise group (n = 24). Measures of pain and SNS function were recorded immediately before and after a single session of the exercise interventions. Pain measures included visual analogue scale (VAS) ratings of neck pain at rest and during active cervical motion and pressure pain threshold (PPT) and thermal pain threshold (TPT) recordings over the cervical spine and at a remote site on the leg. Measures of SNS function consisted of blood flow, skin conductance, skin temperature, heart rate, and blood pressure. Immediately after 1 session of exercise, there was a reasonably sized increase of 21% (P < .001, d = 0.88) and 7.3% (P = .03, d = 0.47) in PPT locally at the neck for the CCF exercise and the CF exercise, respectively. There were no changes in local neck TPT with either exercise. Pressure pain threshold and TPT at the leg and SNS did not change after exercise. Only the CCF exercise demonstrated a small improvement in VAS ratings during active movement (change on 10-cm VAS: CCF, 0.42 cm (P = .04)). This study shows that specific CCF therapeutic exercise is likely to provide immediate change in mechanical hyperalgesia local to the neck with translation into perceived pain relief on movement in patients with chronic neck pain.

Perspective: This study showed an immediate local mechanical hypoalgesic response to specific exercise of the cervical spine. Understanding the pain-relieving effects of exercise will assist the clinician in prescribing the most appropriate exercise protocols for patients with chronic neck pain.

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Key words: Neck pain, therapeutic exercise, hypoalgesia, pain modulation.
vical spine movement, immediately after the performance of their first session of cervical muscle exercise. This seems unlikely to be fully explained by enhancement of muscular performance that has been reported after several weeks of training in clinical trials.\textsuperscript{18,50}

Specific exercise of neck muscles may have other systemic effects on the modulation of pain often referred to as "exercise-induced hypoalgesia."\textsuperscript{20} Immediate hypoalgesia to noxious stimuli after exercise has been shown in response to aerobic,\textsuperscript{9-12,19,22,29} dynamic resistance,\textsuperscript{21} and isometric exercise.\textsuperscript{23,24} Identification of hypoalgesia in body regions remote to those being exercised suggests that a systemic analgesic process may be responsible.\textsuperscript{11} Although specific exercise to train neck muscles differs in characteristics (exercise intensity and duration) from other exercise forms such as aerobic exercise, we speculate that they may exhibit similar immediate pain modulation effects. This hypothesis is based on previous studies investigating the pain-modulating properties of cervical manual therapy. Manual therapy, similar to specific exercise of neck muscles, uses gentle movement of cervical spine structures and has been shown to elicit hypoalgesia both local and remote to the cervical spine, concurrent with sympathetic nervous system (SNS) excitation,\textsuperscript{36,42} suggestive of systemic pain modulation effects.

The purpose of this study was to investigate the immediate pain-modulating properties (to mechanical and thermal stimuli) of specific therapeutic exercise involving the neck, both at sites local and remote to the cervical spine. In addition, we aimed to investigate whether these effects, if present, were dependent on the type of exercise intervention. We compared the analgesic effects of a cranio-cervical flexion (CCF) coordination exercise protocol\textsuperscript{15} with that of a more conventional cervical flexion (CF) endurance exercise protocol that uses the resistance of head weight.\textsuperscript{2,8,30,38,50} Both forms of exercise are commonly prescribed in the clinical management of neck pain, and although both train the cervical flexor muscle group, they differ in their motion characteristics (Fig 1) and intended cervical flexor muscle adaptations.

The emphasis of CCF coordination training is on activation of the deep cervical flexor muscles (longus capitus, longus colli)\textsuperscript{15} by specifically targeting flexion motion of the upper cervical motion segments.\textsuperscript{26} This intervention has been shown to improve the temporal control of the deep cervical flexor muscles\textsuperscript{14} and proprioception of the neck,\textsuperscript{16} as well as leading to changes in pain and disability in painful neck disorders.\textsuperscript{18} In contrast, the emphasis of the CF exercise protocol is on flexion motion at the lower cervical motion segments, training the endurance of the entire cervical flexor muscle group,\textsuperscript{26} using a standardized endurance training protocol.\textsuperscript{1} This intervention has been shown to reduce the fatigability of the cervical flexor muscles and improve pain and disability in people with neck pain.\textsuperscript{5}

With regard to the immediate effects on pain, we hypothesized that exercise for the neck will have immediate hypoalgesic effects on local painful cervical spine structures. We also aimed to establish whether these forms of exercise induce immediate systemic analgesic effects, as would be indicated by hypoalgesia remote from the exercised cervical spine, and signs of sympathoexcitation. This model has been used previously to investigate the analgesic effects of manual therapy.\textsuperscript{33,42,43,45,48}

Materials and Methods

Study Design

An independent-group, repeated-measures study design was adopted to investigate the immediate analgesic and SNS responses to the 2 therapeutic exercise interventions. A person who was independent from the delivery of treatments and the measurement of outcomes used a randomly generated set of numbers to randomly allocate participants to either the CCF exercise or CF exercise intervention. Pain and SNS measures were recorded immediately before and after the exercise intervention during the experimental session. The investigator responsible for all measures was blinded to the exercise group allocation of the participant.

Figure 1. Motion characteristics of exercise protocols. Dotted and solid lines depict starting positions and end range flexion positions of each exercise, respectively, for both the cranio-cervical flexion (CCF) coordination exercise protocol (a) and the cervical flexion (CF) endurance exercise protocol (b). CCF exercise involves a nodding "yes" movement of the head such that it remains in contact with the supporting surface, flexion motion occurring predominantly about the upper cervical motion segments. In contrast, the head is lifted off the supporting surface during the CF exercise and flexion occurs predominantly about the lower cervical motion segments.
Subjects
Forty-eight female volunteers participated in the study: CCF exercise group (n = 24; age [mean ± SD], 41.1 ± 9.5 years); CF exercise group (n = 24; age, 41.2 ± 11 years). Only female participants were included in this study to avoid potential confounding by gender differences in pain perception that has been reported in response to exercise.23 All participants reported a history of neck pain of 3 or more months’ duration and scored 5 or greater of 50 on the Neck Disability Index (NDI) (NDI: CCF exercise group, 13.4 ± 5; CF exercise group, 13.3 ± 4.2).39,40 The NDI is a self-reporting instrument for the assessment of perceived pain and physical disability of participants with neck pain. A score of 13 reflects the higher end of mild to moderate neck pain and disability.37,39,40

Participants were excluded if they had undergone training for their neck muscles in the preceding 6 months, if they had neck pain from nonmusculoskeletal causes, had signs of neurological involvement, or had any other medical disorder that would contraindicate physical exercise. After receiving verbal and written information about the study, each participant signed a consent form that was in accordance with the Declaration of Helsinki and had been granted ethical clearance by the University of Queensland Medical Research Ethics Committee.

Pain Measurements
All pain and SNS measures were made in an environmentally controlled laboratory (noise attenuated, temperature = [mean ± SD]; 23.3° ± 0.5°C, relative humidity = 62.1% ± 5.0%).

Before the exercise session, participants rated their level of neck pain at rest on a Visual Analogue Scale (VAS); a 10-cm sliding scale anchored by the descriptors “no pain” and “worst pain imaginable.”

Pressure pain threshold (PPT) was measured with an electronic algometer (Somedic Production, Stockholm, Sweden) over the most symptomatic cervical motion segments and over the tibialis anterior muscle of the leg. Five measurements were recorded at each site. The algometer probe tip was applied to the skin at a rate of 40 kPa/s, and the participant was instructed to depress a handheld switch at their first perception of pain, at which point the application of pressure ceased. The algometer is factory calibrated to 3% of readout and is regularly recalibrated in the laboratory with a 100-kPa calibrating weight before experimentation.

Thermal pain threshold (TPT) was measured with the use of a Thermostest System (Somedic AB, Sollentuna, Sweden) over the most symptomatic cervical motion segment and over the tibialis anterior muscle of the leg. Five measurements were recorded at each site. A ceramic thermode was applied over the skin and the temperature of the thermode gradually increased from 30° to 50°C at a rate of 1°C/s. The participant was requested to depress a handheld switch at their first perception of pain. The Thermostest System is factory calibrated to 0.2°C with a resolution of 0.2°C.

Pressure and thermal pain threshold measures have been shown to be reliable (ICC 0.85-0.9) with low measurement error (SEM; pressure pain threshold, 9.4 kPa; thermal pain threshold, 0.39°C).28

Sympathetic Nervous System Measurements
Skin conductance provides an indicator of sweat gland activity7 and was monitored (AT64; Autogenics, Wood Dale, IL) bilaterally with silver skin conductance electrodes attached to the glabrous skin over the index and middle fingers of both hands after skin preparation with alcohol.36

Blood flow is a measure of tissue blood flow and was measured with a laser Doppler blood flow monitor (Moor Instruments Ltd, Devon, UK)36 over the affected side of the cervical spine and ipsilateral thumb.

Skin temperature was monitored (AT42; Autogenics) with sensors positioned over the palmar surface of both thumbs and over the affected side of the cervical spine after skin preparation.36 Skin conductance, blood flow, and skin temperature data were acquired (National Instruments, Austin, TX) and sampled at 20 Hz.

Blood pressure was measured with a semiautomatic digital sphygmomanometer (Model DS-115; Omron Nohgata Co Ltd, Fukuoka, Japan) attached to the left arm in all participants. In addition, a heart rate monitor (Polar Beat; Polar Electro Oy, Kempele, Finland) was placed around the chest at the level of xiphoid process to detect the cardiac activity and provide a measure of heart rate.25,41

Sympathetic nervous system measurements have been shown to have acceptable reliability (ICC 0.68-0.99) and measurement error (SEM: heart rate, 2.5 beats per minute; systolic blood pressure, 1.6 mm Hg; diastolic blood pressure, 1.8 mm Hg; blood flow, 0.008 flow units/min; skin conductance, 0.011 siemens; temperature, 0.0002°C).28

Exercise Interventions
The exercise conditions were the Cranio-Cervical Flexion Co-ordination Exercise and the Cervical Flexion Endurance Exercise. A control (no exercise) group was not included because previous studies performed in our laboratory investigating pain modulation mechanisms (pre-post intervention) have reported negligible change in the measures used in this study (measures taken both local and remote to the cervical spine) before to after intervention within their control group data.28,36,42

Cranio-Cervical Flexion Coordination Exercise
Participants performed a CCF exercise in the supine position. This task involves flexion of the cranium on the cervical spine while ensuring the back of the head remains in contact with the supporting surface (Fig 1a) in an effort to facilitate activation of the deep cranio-cer-
cervical flexor muscles with minimal activity of the superficial cervical flexors. The contraction is graded through feedback from a pressure biofeedback device (Stabilizer; Chattanooga Group Inc., Chattanooga, TN) that monitors and grades the flattening effect of the cervical lordosis due to the CCF movement from contraction of the deep cervical flexor muscles. In the familiarization session, participants first attained the correct CCF action. Once the correct action had been achieved, the highest pressure increment (ranging between 22 and 30 mm Hg) at which the participant could comfortably maintain a 10-second contraction with no pain was established. During the experimental session (no sooner than 48 hours after the familiarization session), participants sustained the contraction at the level determined in the familiarization session for 10 repetitions of 10-second duration, with a 10-second rest interval between each contraction (total contraction time = 100 seconds, total time of session = 190 seconds).

Cervical Flexion Endurance Exercise

Participants performed a head lift exercise in the supine position. The head lift exercise was taught, ensuring that the cranio-cervical spine was maintained in a neutral position while the head was lifted no further than 2 cm above the supporting surface (Fig 1b). During the familiarization session, each participant's pain-free 12-repetition maximum (12RM) was assessed. If the participant could perform 12 repetitions lifting head weight and reported fatigue at the completion of the repetitions but not pain, then this became the exercise for the experimental session. If they were unable to perform 12 repetitions with head weight only, or if pain was present, the pressure biofeedback device was positioned under the occiput, inflated to 40 mm Hg, and the patient was instructed to lift the head until the pressure reduced by 10 mm Hg. If the participant was still unable to perform 12 repetitions in this manner, they were instructed to lessen the pressure change further, until 12 repetitions could be performed. Conversely, if 12 repetitions were performed easily with head weight, half-kilogram weight increments were added to the forehead until the 12RM was found. During the experimental session, participants performed 3 sets of 10 repetitions at the pre-determined intensity level, consistent with standardized endurance protocols. Each repetition lasted 3 seconds, with rest intervals of 2 seconds between repetitions. Subjects rested for 30 seconds between sets (total contraction time = 90 seconds, total time of session = 204 seconds).

Experimental Procedure

After inclusion into the study and randomization into an exercise group, participants attended the familiarization session. Participants were assessed on their ability level for the exercise so that an appropriate intensity level could be chosen at which they would perform the exercise during the experimental session. Exercise doses were selected at a level that the patient could perform comfortably without provocation of neck pain or fatigue. During the session, participants were also familiarized with the pain and SNS measures and the side and level of their 2 most symptomatic cervical motion segments was established by manual examination. An interval of at least 48 hours was given between the familiarization and the experimental sessions during which participants were instructed not to practice the exercise. Participants were also asked to avoid the consumption of stimulants (eg, caffeine and nicotine products) or analgesic drugs for at least 8 hours before the study, as well as to avoid heavy exercise for 4 hours before the study.

In the experimental session, participants were first asked to rate their current pain at rest on the VAS in standing. Active movements were performed in the following order: Cervical flexion, extension, right rotation, and left rotation and rated on the VAS any increase in pain experienced during each movement. Participants were then positioned prone and PPT and TPT recordings were made at the cervical spine sites. In supine position, recordings were made over the tibialis anterior muscle of their leg. The SNS electrodes, heart rate monitor, and blood pressure cuff were then attached and the baseline recording of blood pressure was taken. The participant was encouraged to rest, and the investigator who supervised the exercise intervention sat quietly near the head of the participant. The other investigator monitored the participant’s SNS recordings displayed on a computer located outside of the laboratory. When the participants’ SNS recordings stabilized, baseline recordings of SNS parameters were made for 60 seconds. The exercise intervention was then performed as practiced in the familiarization session. After the completion of the exercise intervention, the participant was instructed to remain relaxed for a further 60 seconds, during which measures of SNS activity were repeated. The PPT, TPT, and VAS (resting pain and pain during active movements) measurements were then repeated.

Data Management and Statistical Analysis

Data for all participants were collated according to exercise condition (CCF, CF) and with respect to time (pre- and post-exercise intervention). For all measures in which multiple recordings were made (VAS ratings during active movements, PPT, TPT, heart rate), measures were averaged before analysis. Measures of blood flow, skin conductance, and skin temperature were quantified using the maximum effect indicator (maximum increase or decrease of SNS response based on the relative direction of the response), as has been described previously.

Mean data and the upper and lower 95% confidence limits for all pain (VAS rest, VAS active movement, PPT (symptomatic cervical motion segment segments ×2, leg), TPT (neck and leg) and SNS measurements (dependent variables) were calculated. A 2-way ANOVA evaluated the effect of the factors of group (between subjects: CCF and CF exercise) and time (within subjects:
Table 1. Means and Standard Deviations (Mean Differences (X_{diff}) (Before to After Exercise Intervention) With Lower (LCL) and Upper (UCL) 95% Confidence Limits for the Pain and Sympathetic Nervous System (SNS) Measures Recorded for Participants in the Cranio-Cervical Flexion (CCF) Exercise and the Cervical Flexion (CF) Exercise Groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-Exercise</th>
<th>Post-Exercise</th>
<th>Difference</th>
<th>Pre-Exercise</th>
<th>Post-Exercise</th>
<th>Difference</th>
</tr>
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<tbody>
<tr>
<td><strong>Pain measures</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>VAS (cm) - Rest</td>
<td>0.77 (1.07)</td>
<td>0.57 (1.01)</td>
<td>-0.2 (-0.61 to 0.2)</td>
<td>1.09 (1.52)</td>
<td>0.85 (1.43)</td>
<td>-0.24 (-0.78 to 0.29)</td>
</tr>
<tr>
<td>VAS (cm) - ACT</td>
<td>1.4 (1.03)</td>
<td>0.98 (0.92)</td>
<td>-0.42 (-0.82 to -0.02)</td>
<td>1.55 (1.15)</td>
<td>1.42 (1.07)</td>
<td>-0.14 (-0.39 to 0.12)</td>
</tr>
<tr>
<td>PPT (kPa) - Neck 1</td>
<td>106.38 (42.19)</td>
<td>128.3 (39.61)</td>
<td>21.93 (11.34 to 32.51)</td>
<td>119.2 (44.56)</td>
<td>117.21 (49.79)</td>
<td>8.01 (0.74 to 15.27)</td>
</tr>
<tr>
<td>PPT (kPa) - Neck 2</td>
<td>111.13 (40.49)</td>
<td>126.7 (41.27)</td>
<td>15.58 (4.82 to 26.33)</td>
<td>117.04 (48)</td>
<td>117.21 (49.79)</td>
<td>3.6 (0.74 to 15.27)</td>
</tr>
<tr>
<td>PPT (kPa) - Leg</td>
<td>170.17 (109.76)</td>
<td>186.16 (94.58)</td>
<td>15.99 (-6.8 to 38.78)</td>
<td>194.69 (91.27)</td>
<td>194.98 (88.64)</td>
<td>0.28 (-21.98 to 22.55)</td>
</tr>
<tr>
<td>TPT (°C) - Neck</td>
<td>40.25 (3.09)</td>
<td>39.46 (3.18)</td>
<td>-0.8 (-2.12 to 0.52)</td>
<td>41.15 (3.53)</td>
<td>40.98 (3.52)</td>
<td>-0.17 (-0.88 to 0.54)</td>
</tr>
<tr>
<td>TPT (°C) - Leg</td>
<td>44.94 (2.85)</td>
<td>44.51 (3.12)</td>
<td>-0.42 (-1.53 to 0.68)</td>
<td>42.61 (9.61)</td>
<td>42.87 (9.69)</td>
<td>0.27 (-0.32 to 0.86)</td>
</tr>
<tr>
<td><strong>SNS measures</strong></td>
<td></td>
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<tr>
<td>Neck BF (flow units/min)</td>
<td>0.34 (0.17)</td>
<td>0.32 (0.16)</td>
<td>-0.02 (-0.05 to 0.01)</td>
<td>0.36 (0.28)</td>
<td>0.31 (0.23)</td>
<td>-0.05 (-0.08 to -0.02)</td>
</tr>
<tr>
<td>Hand BF (flow units/min)</td>
<td>0.44 (0.51)</td>
<td>0.38 (0.46)</td>
<td>-0.06 (-0.12 to 0.00)</td>
<td>0.3 (0.23)</td>
<td>0.3 (0.21)</td>
<td>-0.01 (-0.07 to 0.06)</td>
</tr>
<tr>
<td>Left SC (microsiemens)</td>
<td>0.33 (0.15)</td>
<td>0.29 (0.1)</td>
<td>-0.03 (-0.08 to 0.01)</td>
<td>0.28 (0.18)</td>
<td>0.29 (0.2)</td>
<td>0.02 (-0.01 to 0.04)</td>
</tr>
<tr>
<td>Right SC (microsiemens)</td>
<td>0.38 (0.19)</td>
<td>0.34 (0.13)</td>
<td>-0.04 (-0.09 to 0.01)</td>
<td>0.34 (0.2)</td>
<td>0.37 (0.25)</td>
<td>0.03 (-0.01 to 0.07)</td>
</tr>
<tr>
<td>Neck ST (°C)</td>
<td>32.53 (4.39)</td>
<td>32.54 (4.39)</td>
<td>0.01 (-0.09 to 0.12)</td>
<td>32.1 (4.6)</td>
<td>32.07 (4.64)</td>
<td>-0.03 (-0.15 to 0.08)</td>
</tr>
<tr>
<td>Hand ST (°C)</td>
<td>31.19 (3.16)</td>
<td>31.25 (3.29)</td>
<td>0.06 (-0.25 to 0.37)</td>
<td>31.88 (3)</td>
<td>31.95 (3.03)</td>
<td>0.07 (-0.36 to 0.5)</td>
</tr>
<tr>
<td>HR (beats/min)</td>
<td>65.33 (9.98)</td>
<td>65.72 (10.37)</td>
<td>0.39 (-0.66 to 1.44)</td>
<td>65.14 (8.6)</td>
<td>66.22 (7.82)</td>
<td>1.09 (-0.09 to 2.27)</td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>111.14 (12.69)</td>
<td>109.5 (12.48)</td>
<td>-1.9 (-4.69 to 0.89)</td>
<td>115.22 (10.55)</td>
<td>113.73 (12.36)</td>
<td>-1.5 (-4.51 to 1.51)</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>71.75 (10.4)</td>
<td>69.3 (10.01)</td>
<td>-2.45 (-5.55 to 0.65)</td>
<td>74.73 (8.14)</td>
<td>74 (8.99)</td>
<td>-0.73 (-2.86 to 1.41)</td>
</tr>
</tbody>
</table>

Abbreviations: VAS, Visual analog scale at rest and during active movements (ACT); PPT, pressure pain thresholds at the most symptomatic (Neck 1) and second most symptomatic (Neck 2) cervical motion segments and at the leg; TPT, thermal pain thresholds at the symptomatic segment of the neck and at the leg; SNS, sympathetic nervous system measures, including BF, blood flow recordings at the neck and hand (minimum values); SC, skin conductance recordings at both hands (maximum values); ST, skin temperature recordings at the neck and hand (minimum values); HR, heart rate; BP, blood pressure.

*Significant within-group change pre-post exercise intervention \( (P < .05) \).
†Significant between-group interaction pre-post exercise intervention \( (P = .03) \).
increase of 3.6 kPa. There was no group by time interaction effect (F1,46 = 2.6, P = .11) or group effect (F1,46 < 0.01, P = 1.0). There was a significant time effect (F1,46 = 6.67, P = .01), which, on post hoc testing, was seen to be a function of the CCF exercise (P = .006, d = 0.61), not the CF exercise (P = .5). There were no significant changes of PPT at the remote leg location (F1,46 = 1.12, P = .3) for either group.

No significant changes in TPT were found at either the neck or the leg (F1,46 = 1.79, P > .19). Table 1 shows the data before and after exercise for both groups.

### Sympathetic Nervous System Measures

Statistical analysis revealed that the only significant change in SNS activity was a reduction of the blood flow measurements of the neck after CF exercise (P = .002, d = 0.44). All other SNS measures did not change significantly after either the CCF exercise or CF exercise (Table 1).

### Discussion

Specific exercise to retrain cervical spine muscle function is advocated in the management of neck pain. It is speculated that one mechanism of efficacy of cervical muscle training is enhancement of muscular support to cervical vertebral structures. The results of this study suggest that specific muscle training of the neck may also have immediate localized hypoalgesic effects. However, these effects may be dependent on the type of exercise intervention. Our data showed that CCF exercise produced the most significant immediate localized hypoalgesic effect. This improvement was in the order of 14% to 21% of pre-exercise PPT levels as opposed to 3% to 7% change for the CF exercise, which is reflected in the effect sizes (d) of 0.61 to 0.88, and 0.14 to 0.47, for the CCF and CF exercise groups, respectively. Neither exercise intervention (CCF, CF) for the cervical muscles had an effect on pain measures at the remote leg site, nor was there any indication of SNS excitation after exercise, either of which might have provided an indication of a more systemic effect of the neck exercises.

There was a small but significant reduction in pain during active movement post-exercise after the CCF exercise (VAS reduced by 0.42 cm, P = .04). This small improvement probably reflects the relatively low level of pre-exercise pain intensity on active movement scored by both groups (1.4 to 1.6 cm on 10 cm VAS). Greater changes in pain measures may have been realized in a population sample of greater neck pain and disability severity. Nevertheless, the changes in pain reported in our groups are somewhat consistent with reductions in tenderness to cervical palpation and reductions in pain during active neck movement that are often reported clinically by patients immediately after therapeutic exercise interventions.

Another possible explanation for the superior hypoalgesic effects of the CCF exercise protocol lies in the preponderance of upper cervical spine dysfunction found in participants in this study. On manual examination of the cervical spine at the first pre-experiment session, the examining physiotherapist nominated the C2/3 motion segment as the most symptomatic cervical motion segment in 85% of participants. The CCF exercise protocol specifically involves an upper cervical spine flexion action, as opposed to the CF exercise that specifically involves a lower cervical spine flexion action (upper cervical motion segments are maintained in a neutral position). By means of this difference, the CCF exercise may directly influence pain-sensitive structures of the upper cervical region more than does the CF exercise. In future studies participant subgroups (upper and lower cervical dysfunction) should be stratified to clarify comparisons between these 2 exercise protocols. Nevertheless, the study demonstrates that specific exercise of the cervical muscles does induce immediate hypoalgesia to painful cervical spine structures.

It would appear that the cervical spine exercises used in this study have different immediate analgesic effects from that of whole-body aerobic exercise. Immediate hypoalgesic responses to noxious stimuli applied to the fingers and dental pulp have been demonstrated in individuals immediately after aerobic exercise of the lower limbs such as cycling and running. Thus aerobic exercise appears to have immediate systemic pain modulating properties that was not evident for the cervical exercise protocols used in this study perhaps reflecting the differences in characteristics of these different exercise forms. Compared with the intensity and duration of aerobic exercise previously shown to modulate pain (30 minutes at 75% of VO2max), the cervical exercise programs used in this study were relatively gentle and of short duration (<3.5 minutes). However, passive cervical manual therapy that also involves gentle movement of short duration (<5 minutes) has also been shown to result in concurrent hypoalgesia (both local and remote to the cervical spine) and SNS excitation suggestive of systemic pain modulation. These results infer that cervical spine exercise therapy may have different immediate analgesic effects to that of passive cervical manual ther-
apy, which may be a reason for why these therapies clinically appear to be complimentary. However, similar to manual therapy techniques and aerobic exercise, cervical spine exercise had no effect on TPT. It would appear that mechanical interventions such as manual therapy and exercise have an effect on mechanical pain thresholds and not thermal pain thresholds. By way of contrast, several studies of transcutaneous electrical nerve stimulation have shown it to produce thermal but not mechanical hypoalgesia. Notably, not only was the form of therapy different in these studies but the type of pain state being treated was different such that transcutaneous electrical nerve stimulation was used to treat neuropathic pain (with both thermal and mechanical allodynia) compared with the largely mechanical hyperalgesic pain states treated in the manipulation studies (ie, thermal hyperalgesia was not present). The differing outcomes in different conditions also likely reflect ceiling effects in the pain modalities being studied in addition to the likelihood that different physical treatments exert different stimulatory effects on the endogenous pain control systems. In summary, these findings suggest that mechanical interventions such as medication or heat may find exercise of this nature an effective pain relieving modality potentially as a substitute for, or as a conjunct therapy to, other self-applied pain relieving modalities such as medication or heat.

Future studies will need to investigate the duration of pain relief after this form of specific neck exercise. Nevertheless, previous research of a 6-week program of specific CCF training for subjects with cervicogenic headache has demonstrated a short-term (post-intervention) as well as a long-term (12-month follow-up) reduction in pain on neck movement and palpable tenderness of symptomatic upper cervical joints, which indicates a positive cumulative response to this exercise regime. Aerobic exercise such as cycling has been shown to provide hypoalgesia for time periods of up to 30 minutes after exercise. Further studies also need to establish if similar analgesic effects are found in male subjects, after traumatic neck injuries, or if other forms of cervical spine exercise modulate the pain system more effectively. Studies have shown that there may be gender differences in the analgesic responses to exercise, and traumatic injuries of the cervical spine such as whiplash-associated disorders have shown some sensory, motor, and psychological characteristics that may alter the neck's response to exercise.

For clinicians treating patients with painful cervical spine disorders, the findings of this study offer some support for the prescription of therapeutic exercise as an immediate pain-relieving strategy. Results suggest that specific CCF exercise can be prescribed with the intention of providing immediate reduction of neck pain. Patients may find exercise of this nature an effective pain relieving modality potentially as a substitute for, or as a conjunct therapy to, other self-applied pain relieving modalities such as medication or heat.

References


