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Preliminary evidence for feasibility, efficacy, and mechanisms of Alexander technique group classes for chronic neck pain

Jordan J. Becker[a], Shawn L. Copeland[b], Emily L. Botterbusch[a], Rajal G. Cohen[a,*]

[a] Department of Psychology & Communication, University of Idaho, USA
[b] Lionel Hampton School of Music, University of Idaho, USA

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ABSTRACT

Objectives: To determine feasibility and potential of Alexander technique (AT) group classes for chronic neck pain and to assess changes in self-efficacy, posture, and neck muscle activity as potential mechanisms for pain reduction.

Design: A single-group, multiple-baseline design, with two pre-tests to control for regression toward the mean, a post-test immediately after the intervention, and another post-test five weeks later to examine retention of benefits. Participants were predominately middle-aged; all had experienced neck pain for at least six months.

Intervention: Participants attended ten one-hour group classes in AT, an embodied mindful approach that may reduce habitual overactivation of muscles, including superficial neck muscles, over five weeks.

Outcome measures: (1) self-reports: Northwick Park Questionnaire (to assess neck pain and associated disability) and Pain Self-Efficacy Questionnaire; (2) superficial neck flexor activation and fatigue (assessed by electromyography and power spectral analysis) during the cranio-cervical flexion test; (3) posture during a video game task.

Results: There were no significant changes in outcomes between pre-tests. All participants completed the intervention. After the intervention: (1) participants reported significantly reduced neck pain; (2) fatigue of the superficial neck flexors during the cranio-cervical flexion test was substantially lower; (3) posture was marginally more upright, as compared to the second pre-intervention values. Changes in pain, self-efficacy, and neck muscle fatigue were retained at the second post-test and tended to be correlated with one another.

Conclusions: Group AT classes may provide a cost-effective approach to reducing neck pain by teaching participants to decrease excessive habitual muscle contraction during everyday activity.

1. Introduction

Neck pain is the 4th leading cause of disability in the U,[1] with annual global prevalence around 26%.[2] Possible causes include poor postural alignment and inefficient distribution of muscle activity. Support for a connection between neck pain and postural alignment comes from studies showing that people with neck pain may tend to habitually carry their heads forward from their spines (called forward head posture),[3–5] and that forward head posture increases loading on neck muscles.[6–8] Support for the connection between neck pain and inefficient neck muscle organization comes from studies showing increased activation of the superficial sternocleidomastoid muscles in patients with neck pain, along with an inverse relationship between activation of sternocleidomastoids and activation of deep cervical flexors responsible for support of the cervical spine.[9,10] This can be seen clearly in performance of the *cranio-cervical flexion test* (CCFT), which involves gently flexing the neck while lying supine.[10]

Successful treatment of neck pain by exercise has been associated with decreased activation of the sternocleidomastoids during the CCFT, thought to indicate an appropriate commensurate increase in activation of deep cervical flexors.[11] However, exercise programs can be time consuming, people suffering from pain may find exercise aversive, and compliance may be low.[12–14] In addition, a recent meta-analysis suggests that exercise may not be as effective for neck pain-related disability as previously thought.[15] Therefore, development of an effective non-exercise program that addresses patterns of neck muscle activity could provide an alternative for individuals who are unwilling or unable to participate in exercise programs targeting neck pain, while shining additional light on mechanisms underlying neck pain and recovery.

Abbreviations: CCFT, cranio-cervical flexion test; AT, Alexander technique; NPQ, Northwick Park Questionnaire; PSEQ, Pain Self-Efficacy Questionnaire; ANOVA, analysis of variance

* Corresponding author at: Department of Psychology & Communication, University of Idaho, 875 Perimeter Drive, MS 3043, Moscow, ID, 83843, USA.
E-mail address: rcohen@uidaho.edu (R.G. Cohen).

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One possible alternative to exercise is embodied mindfulness education. Results of studies investigating the effectiveness of education for neck pain have not been encouraging.[16,17] However, ineffective studies have not included information or skills known to be important to musculoskeletal rehabilitation, such as how the spine functions and how to practically apply this knowledge to daily activities.[18]

Alexander technique is a non-exercise-based embodied mindfulness approach that aims to improve overall patterns of postural muscle organization by teaching people to observe and inhibit habitual patterns of reaction while maintaining an intention of length and integration.[19–22] Importantly, AT principles and skills are meant to be applied in everyday activities, rather than being tied to particular exercises. In a recent randomized controlled trial, 20 one-to-one AT lessons led to reduced neck pain and increased self-efficacy compared to usual care, with higher self-efficacy associated with lower neck pain scores one and seven months after lessons were completed.[23] This is a promising result; however, one-to-one lessons may be cost-prohibitive for some people. AT is often taught in groups.[24–26] but the present study is the first to examine the feasibility or efficacy of AT group classes for people with neck pain. If group classes in AT lead to reduce neck pain and improve pain self-efficacy (as was found for one-to-one lessons), this could provide a cost-effective intervention.

The present study also investigated three possible mechanisms by which learning and applying the AT might reduce neck pain. If changing postural alignment is an important AT mechanism, the AT intervention should lead to reduced forward head posture, associated with reductions in pain. If AT alters patterns of postural muscle activation by inhibiting excessive contraction of superficial muscles, leading to more efficient overall self-organization of skeletal muscles,[27–30] the intervention should lead to decreased sternocleidomastoid activation and fatigue during CCFT, associated with decreased neck pain. If AT alters coordination through increased understanding, awareness, and ability to choose more comfortable posture and movement patterns, the group AT intervention should lead to increased self-efficacy.

2. Methods

2.1. Design

This single group pilot study began with two baseline data collection sessions (B1 and B2) spaced five weeks apart to determine if there was regression towards the mean (spontaneous recovery). Following B2, participants completed five weeks of AT classes (ten meetings, twice per week), followed by two post-intervention testing sessions (P1 and P2). The first testing session was administered immediately after the intervention; the second testing session was administered 5 weeks later to assess retention of benefits.

2.2. Participants

Participants were recruited through radio ads, flyers, and the University of Idaho employee newsletter. Volunteers were screened through an online survey and were invited to participate in the study if they scored > 8/50 on the Neck Disability Index), reported at least six months of neck pain, and had not received specialized treatment for neck pain within the past six months.[31] Participants were excluded if they indicated they could not attend all classes and testing sessions. Ten participants (eight women, two men; age 48 ± 10 years) completed all testing sessions and the intervention. Participants consented to take part in the study according to a protocol approved by the University of Idaho's institutional review board (#16-1131). Testing took place in the Mind in Movement Laboratory on the University of Idaho campus. See Table 1 for additional demographic information.

2.3. Intervention

AT classes were held from 6 to 7 pm on Mondays and Fridays in a rehearsal room on the University of Idaho campus and were delivered by a certified trained AT teacher (co-author SLC, member of Alexander Technique International, mATI). Participants were taught AT principles and skills that would allow them to notice unproductive habits of muscle tension and to become aware of the possibility of making different choices. The AT classes included instruction in basic biomechanical and ergonomic principles (including anatomy of the neck, spine, and major joints of the upper and lower limbs) and advantages of maintaining an external focus during activity. In addition, participants were guided in self-observation during everyday activities such as standing, sitting, computer work, texting, driving, household chores, and personal care tasks. Hands-on work was used occasionally to demonstrate how to maintain a fluid connection between the head and spine during activities.[22] On average, each participant received about one minute of hands-on contact per week. Games and partner activities such as tossing and catching were included to create a structure for exploration in a fun, low-stakes context.[24] A typical class began with ten minutes for participants to share observations and ask questions, followed by 20 min of instruction on new material, 20 min of activities and games, and ten minutes of discussion, questions, and planning of individualized application of the material to specific activities.

2.4. Outcomes

Each testing session included three parts: (1) Self-report; (2) Electromyography of sternocleidomastoid activity during CCFT[9]; (3) Assessment of forward head posture during a 5-min video game task.

2.4.1. Self-report measures

Our primary outcome measure was the Northwick Park Questionnaire (NPQ), a 9-item questionnaire assessing severity of neck pain and disability during activities of daily living.[32] Each item is scored from 0 to 5 and then summed.

The Pain Self-Efficacy Questionnaire (PSEQ) is a 10-item questionnaire assessing confidence regarding performance of daily activities despite neck pain.[33] Each item is scored using a 7-point Likert scale, where 0 = not confident at all and 6 = completely confident, and item scores are summed for a total score.

At P1, we administered a survey about participants' experience of the AT classes. At P2 we administered a survey asking participants how consistently they were applying what they had learned.

2.4.2. Electromyography

Prior to electrode placement, skin was prepped by shaving any hair, lightly abrading with sand paper tape[a], and cleansing with 70% isopropyl alcohol. Single Bagnoli[b] DE-2.1 Ag-AgCl electrodes were placed bilaterally on the sternocleidomastoids approximately 2/3 of the way down the muscle, close to the manubrium. Electrode placements were obtained from previous studies of the CCFT[10] and were based on palpation during supine neck raises and rotations. Data were collected and pre-processed with the MotionMonitor Classich software.

Following electrode placement, participants performed a reference voluntary contraction while lying supine. The reference value was obtained by having participants hold their heads approximately 3 inches off the floor for 10 s while muscle activity was recorded. Three reference contractions were recorded to ensure a reliable measurement and later averaged during data analysis.

2.4.3. CCFT

CCFT was administered using a standard clinical protocol adopted from Jull et al.[9] Participants lay supine, with a Chattanooga biofeedback unit[c] under the neck touching the external occipital protuberance to provide visual feedback to the participant and experimenter. The

Table 1
Demographic information for participants who completed the study.

Participant Number	Occupation	Time at Job	Sitting (Hours/ Day)	Age (Years)	Sex (F/ M)	Height (cm)	Mass (kg)	Education (degree)	Classes Completed
1	Library Technician	3 Years	6	48	F	152.4	58.9	Bachelor's	10
2	Outreach Coordinator	3 Months	5	45	F	165.5	77.0	Master's	7
3	Accountant	30 Years	6	52	F	162.6	63.5	Master's	8
4	Teacher	6 months	3	37	F	160.0	61.2	Bachelor's	9
5	Implementation Specialist	33 Years	8	61	F	154.9	52.2	3 Yrs College	10
6	Computer Specialist	37 Years	16	57	F	167.6	90.6	Master's	9
7	Mechanic	40 Years	1	54	M	172.2	63.5	Trade school	7
8	Technical Support	3 Years	8	28	F	157.5	81.6	Bachelor's	10
9	Landscape Specialist	4 Years	4	57	M	182.9	81.5	Bachelor's	7
10	Fiscal Specialist	4 Years	7	44	F	162.6	83.9	High School	8

pressure sensor responded to the slight retraction of the neck normally caused by contraction of the deep cervical flexors.[34] The sensor was inflated to 20 mmHg at baseline, and participants practiced obtaining the required levels in 2 mmHg increments (22–30 mmHg). The CCFT consists of all 5 levels in ascending sequence, with participants instructed to hold each level for 10 s while muscle activity is recorded. Three trials were recorded at each level, and participants rested 30 s between each trial. Electromyography recording was initiated when the participant reached a stable and accurate pressure. After each recording, pressure was returned to 20 mm.

2.4.4. Video game

Participants played Diner Dash[d], a computer game with simple rules and increasing difficulty, for five minutes. The game involves pointing and clicking with a mouse to serve patrons in a virtual restaurant. Participants read the instructions and practiced for five minutes before recording commenced. Reflective markers were placed at tragus, C7, and manubrium to allow assessment of postural alignment. Two-dimensional static images were recorded once per minute using a camera on a tripod to examine movement in the sagittal plane. Before participants began playing, the experimenter adjusted the chair, table, and monitor positions in accordance with the participant's anthropometry per OSHA standards.[35]

2.5. Data analysis

Electromyography data were analyzed using a custom MATLAB[e] script. Muscle activity amplitude was obtained by calculating the root mean squared value of each signal over 50-ms windows and then averaging across all windows. Amplitude was averaged across the three trials at each level of the CCFT and expressed as a percentage of reference values. Amplitudes for left and right sternocleidomastoid were compared. Since no difference was found, left and right values were averaged.

As muscles fatigue, the frequency of motor unit discharge decreases, and the median power spectral density of the electromyography signal decreases commensurately.[36] Therefore, we assessed neck muscle fatigue during the CCFT by computing the median value from the power spectral density function of the muscle signal at each level. Fig. 1 shows an example of frequency shift due to increased fatigue of the sternocleidomastoids.

Postural alignment was analyzed from still images using the ImageJ software[f]. Forward head posture was operationally defined based on the angle between the tragus, the spinous process of the seventh cervical vertebra (C7), and the top of the manubrium, with a smaller angle indicating a more forward head posture.

2.6. Statistical analysis

Statistics were analyzed in SPSS[g], with alpha set at 0.05. Due to the small sample size, near-significant results ($p < .10$ for ANOVAs and $p < .20$ for correlations) are also reported.

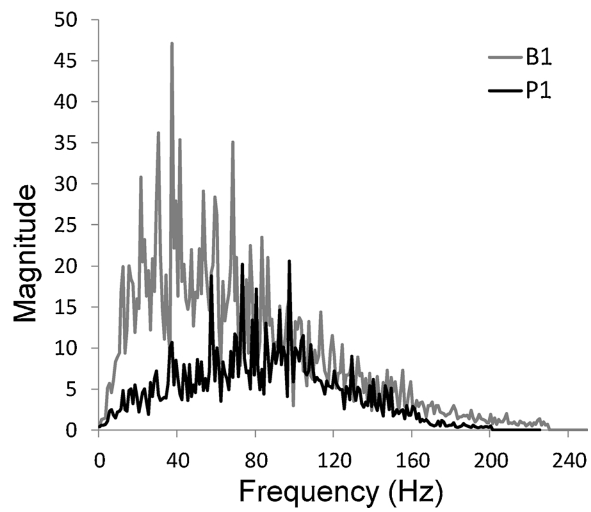

Fig. 1. Raw power spectral density function from one participant in this study, before and after AT intervention. Lower frequencies signify increased muscle fatigue. (B1 = 1st baseline; P1 = 1st post-intervention testing session.).

A one-way repeated-measures analysis of variance (ANOVA) was used to analyze each dependent measure. For results in which Mauchly's *W* was significant, we applied the Greenhouse-Geisser correction for non-homogeneity. Significant and near-significant ANOVA results were followed with pairwise post-hoc comparisons, using Bonferroni correction. Effect sizes are reported as eta^2; these are described as small, medium, or large according to convention.[37]

To assess possible AT mechanisms, we examined relations between changes in neck pain before and after the intervention and changes in other outcome measures, using Pearson's product-moment correlation.

3. Results

3.1. Recruitment, screening, and attendance

Seventy people responded to our recruitment advertising. Forty-four were excluded for insufficient pain or had recently received specialized treatment. Nine were excluded based on scheduling conflicts, and seven dropped out after B1 (one of these found the CCFT too uncomfortable; the others reported scheduling conflicts). All ten participants who began the class series also finished it (attending 85% of the classes, on average) and participated in both post-intervention test sessions. Table 1 reports participant characteristics and number of classes attended.

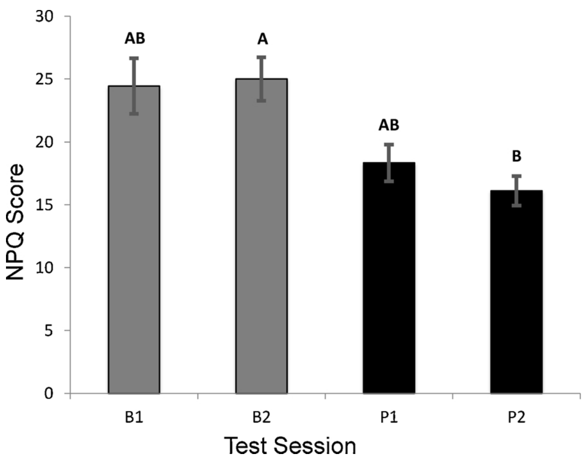

Fig. 2. Average score on Northwick Park Questionnaire (NPQ) for each testing session. Decreases in NPQ score indicate reduced neck pain and associated disability. Error bars indicate standard error. Differences between bars labeled A and B are significant from one another. Bars labeled AB are not significantly different from A or B. (B1 = 1st baseline; B2 = 2nd baseline; P1 = 1st post-intervention; P2 = 2nd post-intervention).

3.2. Self-reports

Fig. 2 shows average NPQ scores across testing sessions. Nine of ten participants reported a decrease in pain/disability, and there was a significant effect of session, $F(3,27) = 5.1$, $p = .007$. The effect was large, $eta^2 = 0.36$. Post-hoc pairwise comparisons indicated a significant decrease in neck pain/disability from B2 to P2, $p = .008$.

Fig. 3 shows PSEQ scores across testing sessions. PSEQ score was not significantly different across testing session, but it did increase in nine of ten participants after the intervention.

Tables 2 and 3 show the results of the two post-intervention surveys. Participants indicated that they enjoyed the group AT classes, they learned how their habits contributed to their neck pain, they appreciated the group nature of the intervention, and they acquired practical tools to be more comfortable in their bodies.

3.3. Sternocleidomastoid activation and fatigue

Fig. 4 shows sternocleidomastoid activation as percentage of reference voluntary contraction across testing sessions and CCFT levels. CCFT level affected sternocleidomastoid activation, with greater electromyography amplitudes at higher CCFT levels, $F(2.3,21) = 13.0$, $p < .001$. This was a large effect, $eta^2 = 0.59$. In addition, the effect of testing session approached significance, $F(3,27) = 2.6$, $p = .07$. The effect was large, $eta^2 = 0.23$, with lower sternocleidomastoid activation post-intervention. Post-hoc pairwise comparisons indicated a significant difference between levels 22 and 30 on the CCFT, $p = .02$, and a near-significant difference between B2 and P1, $p = .10$. There was no interaction between testing session and CCFT level.

Fig. 1 shows one trial of the raw power spectral density from one

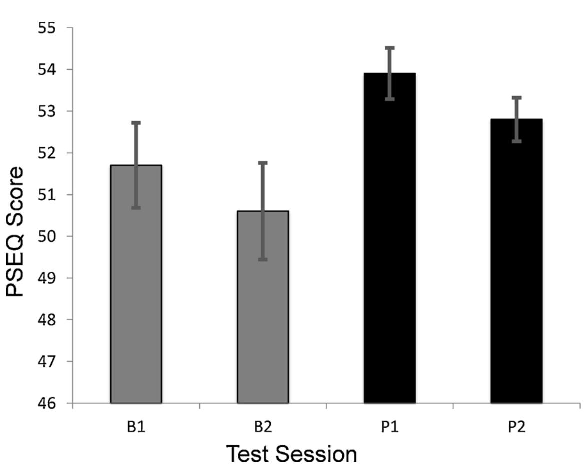

Fig. 3. Average score on Pain Self-Efficacy Questionnaire (PSEQ) for each testing session. Higher score indicates higher self-efficacy. Error bars indicate standard error. (B1 = 1st baseline; B2 = 2nd baseline; P1 = 1st post-intervention; P2 = 2nd post-intervention).

Table 2
Means and standard deviations of P1 survey responses (0–10 scale).

Mean (SD)	Prompt
9.2 (1.1)	The Alexander Technique class was enjoyable.
9.3 (0.7)	The material was presented in a clear and understandable way.
9.2 (1.3)	I learned about how my habits contribute to my neck pain.
9.3 (0.8)	I was surprised by some of the things I learned.
9.4 (0.8)	I learned some practical tools to be more comfortable in my body.
7.6 (1.1)	I am likely to remember what I learned.
8.3 (1.3)	I am likely to continue to practice what I learned.
9.0 (1.2)	I enjoyed the interaction with my fellow-students.
9.1 (1.7)	I would refer a friend to this class.
6.6 (2.4)	I would pay for continuing classes if they were available.
2.9 (3.1)	I would have preferred a private (one-to-one) lesson format.
4.4 (3.6)	I would have preferred a class that met only once per week.
5.5 (3.5)	I would have preferred a class that met for more than 10 sessions.
4.0 (2.7)	I would have preferred to meet in a “healing” environment such as a yoga studio.
3.3 (3.1)	I would have preferred a class with a more structured format.

Table 3
Medians and modes for P2 survey responses. Response scale: 0 (never); 1 (a few times); 2 (weekly); 3 (every few days); 4 (daily); 5 (more than once/day). * Constructive rest is a term sometimes used to describe an AT practice of lying on one’s back with the knees bent while bringing awareness to the body.

Median, Mode	Prompt
4, 5	I apply what I learned in the class to an activity we practiced in class
3, 1	I apply what I learned in the class to an activity that we did NOT practice in class.
1, 1	I practice “constructive rest” for at least 5 min. *
3.5, 4	I notice myself using a habitual response such as pulling down and choose a different response.

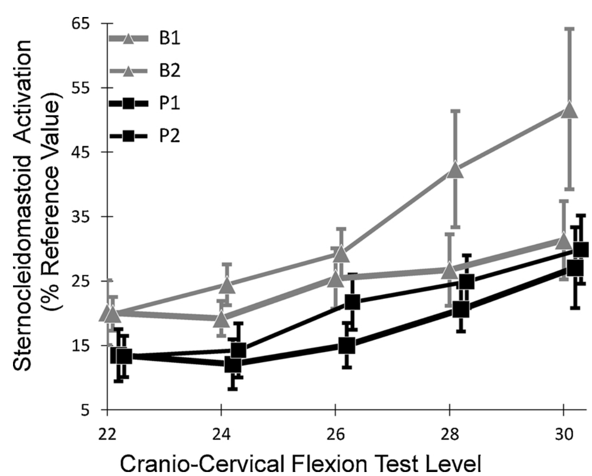

Fig. 4. Normalized bilateral sternocleidomastoid muscle activity across the 5 levels of the cranio-cervical flexion test for each data collection session. Increased percentage of reference voluntary contraction indicates greater sternocleidomastoid activation. Error bars indicate standard error. (B1 = 1st baseline; B2 = 2nd baseline; P1 = 1st post-intervention; P2 = 2nd post-intervention).

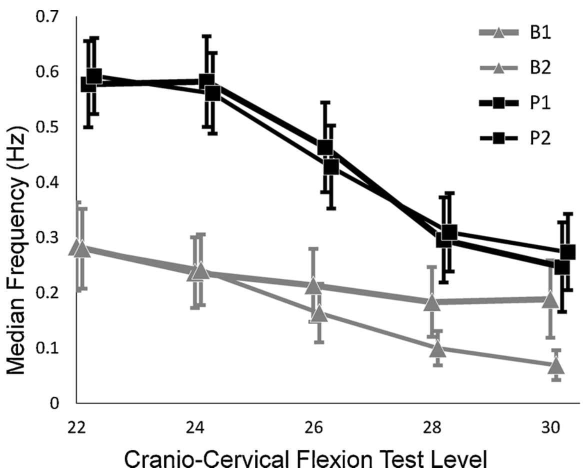

Fig. 5. Average median frequency of sternocleidomastoid muscles across each level of the cranio-cervical flexion test during the four test sessions, according to power spectral density function. Decreased median frequency indicates higher fatigue. Error bars indicate standard error. N = 10. (B1 = 1st baseline; B2 = 2nd baseline; P1 = 1st post-intervention; P2 = 2nd post-intervention).

participant in this study, before and after the AT intervention. Fig. 5 shows the median frequency of sternocleidomastoid activity across sessions and CCFT levels. Unsurprisingly, frequency was lower (indicating greater fatigue) at higher CCFT levels, $F(4,36) = 23.9$, $p < .001$. This was a large effect, $eta^2 = 0.73$. In addition, frequency was higher after the intervention than before the intervention (indicating less fatigue), $F(3,27) = 7.3$, $p = .001$. This effect was large, $eta^2 = 0.45$. Post-hoc pairwise comparisons indicated significant differences between B2 and P1, $p = .049$, and almost significant difference between B2 and P2, $p = .07$. Interestingly, there was a significant interaction between testing session and CCFT level, $F(8.5,77) = 2.2$, $p = .04$. Tests of simple main effects revealed that at the lowest three levels of the CCFT, median sternocleidomastoid frequency was significantly higher (up to double) after the intervention than before the intervention; this effect became less pronounced at the two highest CCFT levels.

3.4. Forward head posture

Fig. 6 shows forward head posture during the video game across testing sessions. There was a near-significant effect of session on posture, $F(3,27) = 2.6$, $p = .07$, $eta^2 = 0.22$. The average angle was marginally higher in P1 than B2, $p = .06$, suggesting a more upright head posture post-intervention.

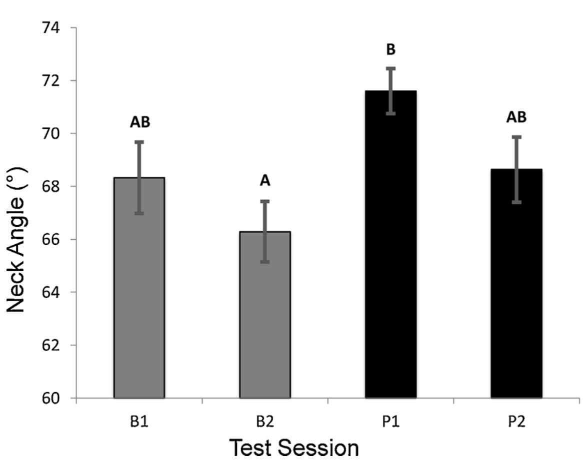

Fig. 6. Average neck angle during 5-min computer task. Increased angle indicates reduced forward head posture during computer game. Error bars indicate standard error. (B1 = 1st baseline; B2 = 2nd baseline; P1 = 1st post-intervention; P2 = 2nd post-intervention.).

Table 4
Pearson's correlations between changes in dependent variables between P2 and B1. Near-significant correlations (based on two-tailed tests) are indicated in bold ($p < .20$) and bold italics ($p < .10$). NPQ = Northwick Park (neck pain) Questionnaire; RVC = reference voluntary contraction; PSD = median power spectral density; PSEQ = Pain Self-Efficacy Questionnaire; FHP = forward head posture.

	NPQ	%RVC	PSD	PSEQ	FHP
NPQ					
% RVC	0.21				
PSD	−0.39	−0.29			
PSEQ	−0.45	−0.10	**0.41**		
FHP	−0.30	−0.25	−0.08	−.026	

3.5. Correlations

Correlations between outcome measures are shown in Table 4. Decreases in neck pain/disability were marginally associated with increases in median muscle firing frequency and pain self-efficacy, and with decreases in forward head posture.

4. Discussion

4.1. Summary of findings

This small preliminary study used a single-group multiple-baselines design to assess the feasibility and effects of a series of AT group classes on neck pain and disability, pain self-efficacy, activation and fatigue of surface neck muscles, and postural alignment. All ten participants who began the class series completed it. After the intervention, neck pain and associated disability decreased, posture was marginally more upright, and surface neck muscles were somewhat less active and markedly less fatigued than before the intervention. Importantly, there were no improvements in any measure between the two baseline assessments, indicating that improvement was unlikely to be due to regression toward the mean. Decreased neck pain/disability, increased pain self-efficacy, and decreased surface neck muscle fatigue after the intervention were all marginally correlated with one another; the reductions in neck pain and fatigue were retained five weeks after the intervention ended.

4.2. Interpretation

Previous randomized controlled studies indicated that one-to-one *lessons* in AT can lead to reductions in neck pain,[23,38] back pain[39] knee pain,[29] and disability in Parkinson's disease.[40,41] However, this was the first study to investigate the feasibility and efficacy of a series of AT *group classes* for people with neck pain. The classes were feasible, as demonstrated by the 100% retention rate, 85% attendance rate, and high subjective ratings. They were also apparently effective, as suggested by the 30% reduction in neck pain and associated disability scores and complete retention of neck pain reduction benefit.

Although the mechanisms by which AT may improve musculoskeletal conditions such as neck pain are not yet well understood, support exists for several explanations. For instance, the present study found a correlation between a decrease in pain disability and an increase in pain self-efficacy. This result supports previous findings and suggests that one way group AT classes may benefit participants is by increasing the students' awareness that they have choices about how they respond to pain or difficulty, thereby increasing their sense of control.[23,40]

A second idea is that group AT classes may alter how people carry themselves, reducing forward head posture.[20] The present results provide weak support for this hypothesis, with a non-significant forward head posture reduction following the intervention and a non-significant correlation between reduced forward head posture and reduced pain. This inconclusive result is unsurprising given mixed results in the literature on the relationship between forward head posture and neck pain.[42–44]

Another mechanism by which AT might have its effects is a shift from over-reliance on easily fatigable surface muscles to greater use of slowly fatiguing deeper muscles. This mechanism is consistent with the logic behind the CCFT, which predicts an association between decreased surface neck muscle activation and decreased neck pain after successful treatment.[9,10] and with previous findings that hands-on AT guidance acutely reduces sternocleidomastoid activity.[30] Our results tend to support this reasoning, although neither the overall decrease in surface muscle activation during CCFT nor the correlation with decreased pain was statistically significant in our study. Stronger evidence for the hypothesis that AT alters muscle activity comes from our fatigue results. Before our intervention, sternocleidomastoid muscles showed clear signs of fatigue even at the first (easiest) level of CCFT. After the intervention, the median frequency of the muscle activity was significantly higher, especially at the first CCFT level, suggesting that the intervention led to a greater reliance on the deep cervical flexors not only during the CCFT[9,10], but also during everyday life, so that the surface muscles were not already fatigued at the beginning of the task. This interpretation is consistent with the approach and philosophy of the AT, which, in contrast to clinically accepted (manipulative and exercise-based) approaches to neck pain, aims to teach people to observe and prevent over-activation of muscles during ordinary activities.[19–21]

The idea that AT reduces over-activation of muscles is generally consistent with studies showing that decreased knee pain following AT lessons correlates with decreased co-contraction of leg muscles during gait in people with arthritis,[29] that AT lessons reduce axial stiffness in people with back pain,[27] that AT-like instructions reduce axial stiffness in people with Parkinson's disease,[45] and that people with extensive AT training have lower axial stiffness and greater ability to modulate that stiffness than age-matched controls.[27] Commonalities between the present results and previous studies suggest that the mechanisms of action for group AT classes overlap with the mechanism of action for one-to-one AT lessons.[29,38,46] Although this study focused on neck pain and neck muscle use, AT does not address the neck in isolation, but rather in relation to the whole person. Our AT intervention focused on building awareness and integration through the whole musculoskeletal system. The holistic nature of the approach may explain why AT has been shown to help people with neck pain,[23] back pain,[47] knee pain,[29] and Parkinson's motor symptoms,[40,48] and also to increase breathing capacity[49] and functional reach.[50] That said, it is also possible that there is something special about the neck. Numerous studies have shown that proprioceptors in the neck have a broad influence on the muscle tone and coordination of the limbs and torso.[51,52] In addition, a recent study found that biofeedback-based proactive selective inhibition of neck muscle activity led to improved balance and efficiency of movement in violinists.[53] Thus, when considering the relation of the neck to the rest of the musculoskeletal system, there is evidence for specific-to-general effects as well as general-to-specific effects such as those demonstrated in the present study.

4.3. Strengths, limitations, and future directions

The examination of muscle fatigue using a frequency-based analysis of the electromyography signal during the CCFT is a novel approach to assessing activation of the neck muscles, and the finding of a significant effect in this measure even with a small number of participants supports the utility of the approach.

This was a preliminary study with a small sample size and no control group. While the multiple-baselines design offers some protection against regression toward the mean as an alternative explanation for our results, we cannot discount the possibility of a general therapeutic effect.[54] As follow-up was only 5 weeks, long-term benefit of group AT lessons is still uncertain. Future, larger studies should compare AT classes to other group interventions, such as exercise or mindfulness classes, and should assess retention of benefits after a longer interval.

The inclusion criteria for the study resulted in the exclusion of a substantial proportion (more than half) of the individuals who expressed interest in the study. These criteria (pain for at least six months, severity of at least 16% on the Neck Disability Index, no other treatments in the past six months) were in line with those used for other neck pain intervention studies.[31] However, it could be argued that the study would have had higher external validity if it had included participants who had recently received (but were not currently undergoing) other treatment.

The five-week, ten-lesson structure was chosen for reasons of expedience. Other AT studies have used different numbers of sessions. A large study of low back pain found that 24 one-to-one AT lessons led to substantially more improvement than six AT lessons, that even six AT lessons led to significantly better one-year outcome than massage, and that combining six AT lessons with daily exercise led to 75% as much improvement as 24 AT lessons.[39] Another study found that five one-to-one AT lessons led to a greater immediate reduction in neck pain than guided imagery but was not significantly better than use of a heating pad.[55] A longer study found that 20 one-to-one AT lessons reduced neck pain relative to usual care, and this benefit was retained at one year.[23] Finally, a recent study found that 20 AT lessons reduced knee pain in participants with osteoarthritis relative to a control group.[29] Further studies are needed to investigate the dose-response relation of group classes, the optimal frequency of sessions, and the relative benefits of group classes vs. one-to-one AT teaching protocols.

4.4. Conclusion

Group AT lessons appear to be a feasible and effective intervention for neck pain. Increased self-efficacy and reduced overactivation in surface muscles during everyday activities are likely to contribute to the effect.

Conflict of interests

The authors declare that they have no conflicts of interest.

Suppliers

a. 3M, McKnight Rd, St. Paul, MN 55144-1000

b. Delsys, 23 Strathmore Rd, Natick, MA 01760

c. Chattanooga Medical Supply, 827 Intermont Rd, Chattanooga, TN 37415

d. Playfirst, 303 2nd Street, Suite 520, San Francisco, CA- 94123

e. Mathworks, 1 Apple Hill Drive, Natick, MA 01760-2098

f. National Institute of Health, 6130 Executive Blvd # 2123, Rockville, MD 20852

g. IBM Corp. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp

h. Innovative Sports Training, 3711 N. Ravenswood Ave., Suite 150, Chicago, IL 60613

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