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Neck/Shoulder Exercise for Neck Pain in Air Force Helicopter Pilots

A Randomized Controlled Trial

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Study Design. The study was a randomized, controlled trial with blinded outcome assessment. A 6-week intervention was followed up directly afterwards and after 12 months.

Objective. The purpose was to evaluate the preventive efficacy of a neck/shoulder exercise regimen for neck pain in air force helicopter pilots.

Summary of Background Data. Neck pain is a significant medical problem in modern military aviation. Research shows neck-muscle dysfunction in subjects with various neck disorders. So far, evidence for neck exercise as prevention or early intervention is sparse, and few trials use randomized controlled design.

Methods. Sixty-eight helicopter pilots on active flying duty with or without neck pain were randomly assigned to a supervised neck/shoulder exercise regimen or a control group receiving no such regimen. The key outcome was change in the prevalence of neck pain cases at the 12-month follow-up, rated for the previous week and the previous 3 months. Secondary outcomes included neck-flexor surface electromyographic activity during active craniocervical flexion and pain-related fear regarding physical activity. In addition, a secondary regression analysis included preintervention predictors that may be associated with change in prevalence of neck-pain cases at the 12-month follow-up.

Results. Eighty-two percent (56/68) of the participants assigned at random completed the intervention and provided data at month 12. Regression analysis showed a reduction in the prevalence of neck pain cases in the exercise group, which was significant for pain ratings during the previous week, OR = 3.2 (95% CI = 1.3–7.8), and previous 3 months, OR = 1.9 (95% CI = 1.2–3.2). Electromyographic activity at the highest contraction level was significantly reduced in the exercise group, $P < 0.05$, whereas no between-groups effect emerged for pain-related fear. Results from the secondary analysis showed that general strength training for more than 1 hour per week before the intervention predicted reduction in prevalence of pain at follow-up.

Conclusion. A supervised neck/shoulder exercise regimen was effective in reducing neck pain cases in air force helicopter pilots. This was supported by improvement in neck-flexor function postintervention in regimen members. However, no effect emerged for pain-related fear. General strength training before the intervention predicted reduction in prevalence of pain at follow-up.

Key words: cervical pain, prevention, EMG; intervention, military pilots, motor control, neck muscles, RCT. **Spine 2009;34:E544–E551**

Neck pain is an important musculoskeletal problem in western countries. About one-third of the general population on average are affected in a year.[1] However, certain occupational environments seem to generate increased risk.[2] Neck pain among helicopter pilots is recognized as a significant medical problem in modern air forces, with an estimated 3- to 12-month period prevalence approaching 50%.[3,4] These pilots' neck pain has been reported as attributed to flying,[5] and interfering with both work and leisure.[4] Further, pilots' cabin head-and-trunk postures have been reported as significant for neck-muscle load[6] and back pain.[3] Also, pilots increasingly use helmet-mounted vision enhancement technology during night missions, adding to the neck workload.[7] Yet preventive strategies for neck pain have not been well investigated in this population.

Altered neck muscle activity is present in individuals with neck pain such as whiplash,[8] or chronic pain,[9] and in helicopter pilots with recurrent neck pain.[5,10] Subjects with neck pain have shown increased electromyographic activity in the superficial neck-flexor muscles when performing discrete upper-cervical flexion,[8,11] a test that aims to activate deep prevertebral neck muscles.[12,13] Further, pain-related fear of movement may be associated with changed muscle activity as shown in civilian subjects,[14] possibly representing behavior that affects the coordination of muscles to prevent further painful movements.[15] While exercise therapy for the management of neck pain is relatively common, evidence that neck/shoulder exercise regimens may mediate adaptational neck muscle responses, or affect fear of movement, is sparse. The few trials with fighter pilots suggest that

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neck-muscle strengthening[16,17] and trampoline exercise[18] may improve neck-muscle performance. To our knowledge, however, none uses randomized design, and none tackles the utility of exercise intervention in helicopter pilots.

The present clinical trial sought to investigate the preventive efficacy of a neck/shoulder exercise regimen in air force helicopter pilots, against a control group receiving no regimen. Main outcome was changes in prevalence of neck pain. Measurements of sternocleidomastoid activity during active craniocervical flexion and pain-related fear about physical activity were studied as secondary outcomes. Based on our clinical experience and previous research,[4,5,10] our main hypothesis was that the regimen would reduce neck pain prevalence and improve neck-flexor muscle function. In addition, several baseline measures were investigated as potential predictive factors for the main outcomes in the secondary analysis of the cohort.

Materials and Methods

Design

This randomized controlled trial had blinded outcome assessments. The pilots were recruited and tested at 2 air force helicopter bases in Sweden. Measurements were obtained before randomization, after the 6-week intervention period, and at month 12. For practical reasons, we were unable to collect electromyographic data at month 12, thus these secondary data were evaluated intermediately for the main outcome only. A randomized block design with numbered containers was stratified for frequency of neck pain ("pain-free," "once/a few episodes during the previous 3 months," "once/a few episodes per month during the previous 3 months," or more episodes). One of the authors (A.M.), not involved in the examination procedure, conducted the randomization. A power calculation at 80% to detect a 50% reduction of neck pain cases (alpha 0.05, 2-sided) with a loss to follow-up of 20% indicated that a sample-size of 34 in each group was needed. The participants received oral and written information about the study and gave informed consent. Confidentiality and the voluntary nature of the measurements were stressed. The study was approved in advance by the Medical Research Ethical Review Board, Stockholm.

Participants

Eligible pilots were those who had logged flying hours during the previous 3 months. Participants were excluded if they flew both helicopters and fixed-wing jet aircraft. Independent observers assessed eligibility and listed volunteers. In advance of the outcome examinations, subjects were screened for further eligibility against the following exclusion criteria: previous cervical neck surgery, neurologic symptoms, serious back pain, participation in neck-training program during the previous 12 months or undergoing neck/shoulder treatment at the time of testing (also described elsewhere[5]). Subjects with planned duty abroad during the intervention period were also excluded.

Intervention. Participants allocated to the exercise group or to a control group, which received no exercise regimen, were encouraged to continue with their ordinary exercise activity. All eligible participants were initially told that there was no present evidence of the efficacy of the present exercise regimen. Participants enrolled to the exercise group were encouraged to continue with the intervention exercises after the intervention period.

Exercise Regimen. An experienced physiotherapist supervised the self-management exercise regimen weekly with individual follow-ups including instruction and manual guidance. Assigned exercises were to be conducted twice daily, but once for those reporting no pain during the previous 3 months or on flying days. Each session lasted 10 to 15 minutes, included 2–4 exercises and allowed a pilot to perform the regimen independently of any clinic or stationary equipment (in the gym, at home, or at the base). Participants received written instructions accompanied with pictures illustrating the exercises. Exercises were individually dosed and progressed by the supervising physiotherapist. In the initial stages/in those reporting ongoing pain, they basically followed the procedure described by Jull *et al*[19] Progression was from nonpostural to postural to load-situated exercises, moving largely from isolated low-load-muscle exercises to synergy endurance-strength exercises (illustrated in Figure 1). Guided by the physiotherapist, the progression was based on the pilot's observed progress towards neck/shoulder motor control and movement quality, rather than on a certain amount of sets and repetitions. Progression caused initial exercises to be replaced with new exercises, thus the number of exercises performed did not increase through the intervention period. The exercise protocol comprised the following:

Nonpostural Exercises. With the subject supine, active craniocervical flexion sought to target deep prevertebral neck muscles,[12,13,20] largely the longus colli and capitis.[21,22] The superficial neck flexors, particularly the sternocleidomastoid muscles which flex the lower cervical spine but extend the upper cervical joints,[23] were not to be activated. Initially, the participants were instructed and manually guided to perform accurate craniocervical flexion while trying to focus on maintaining surface neck flexors relaxed. Then they practiced controlling and holding low-load increment levels of craniocervical-flexion with feedback from an air-filled pressure sensor (Stabilizer, Chattanooga Group, Hixon, TM) behind the neck.[19] The supervising physiotherapist monitored potential surface flexor activity visually, with palpation if necessary. Contraction of the deep prevertebral muscles straightens the cervical lordotic curvature[13,22] and this showed as increase in pressure (mm Hg) on the sensor display unit. Active scapular retraction exercises aimed to target scapular muscles, particularly the trapezius, rhomboid, and serratus anterior. Initially these muscles were guided and trained by emphasizing control and holding at an inner and midmotion range in prone position.

Postural Situated Exercises. Participants were taught to sit upright on a stool in a comfortable, neutral lumbar-lordosis posture and first perform isolated and controlled, low-load increments of active craniocervical flexion and shoulder retraction separately. Synergy exercises were trained by simultaneously performing scapular retraction, craniocervical flexion, and neck rotation, with short holds within the inner rotation motion range. Participants with ongoing pain started with low-load neck rotator isometric resistance exercise.

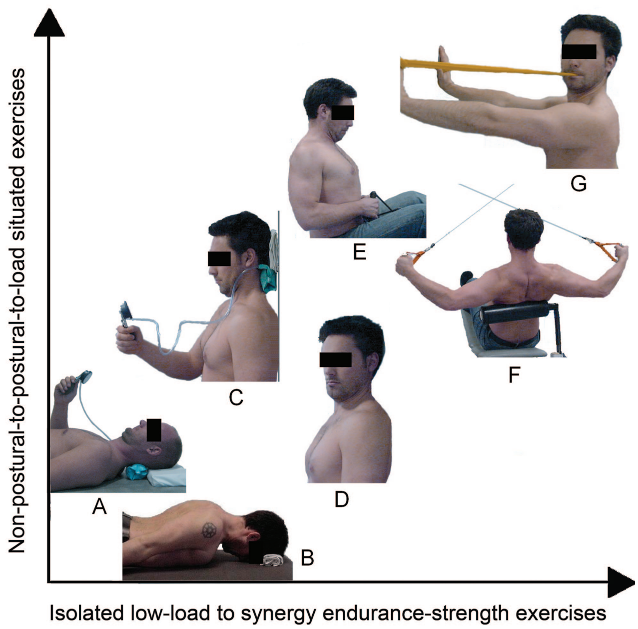

Figure 1. The exercise regimen: the axis represents progression and pictures illustrate selected exercises. An experienced physiotherapist supervised the self-management neck/shoulder exercises weekly with individual follow-ups including instruction and, if needed, manual guidance. Progression, assigned individually, was based on observed progress towards neck/shoulder movement quality.

Nonpostural exercises: **A,** Low-load active craniocervical flexion at 5 pressure levels (22–30 mm Hg), held isometrically for 10s, repeated 10 times, subject trying to focus on maintaining surface neck flexors relaxed. Resistance was given from an air-filled analog pressure sensor placed suboccipitally between neck and bench; head resting on folded towel. **B,** Isometric shoulder/scapulas held against gravity for 10s, repeated 10 times, at a retracted (max- and midmotion range) in prone. Positions were achieved by emphasizing shoulder retracting dynamic movement control.

Postural situated exercises: **C**, In seated position, isometrically held at five pressure levels as in A, i.e., holding 10s, repeated 10 times. **D**, Dynamic synergy exercises: neck rotation to end range with simultaneous scapular retraction to midmotion range and active craniocervical flexion, repeated 10 to 15 times on each side.

Endurance-strength exercises: **E**, Controlled dynamic shoulder retraction following a rowing exercise movement, and (**F**) dynamic scapular retraction with weight load over long moment arms in "rowing" exercises in regular pulls, emphasizing shoulder retraction in the initial concentric phase and upright trunk postures in the inner range, 3 sets of 15 repetitions (elastic bands were used to replicate the exercises at home and/or outdoors). **G**, Dynamic neck rotation exercises in upright posture against moderate resistance using elastic bands. These exercises were initiated with a short craniocervical flexion, short neck extension and then neck rotation; 15 rotations to each side, repeated 3 times.

Endurance-Strength Exercises. Participants practiced controlled, dynamic shoulder retraction in rowing exercises, here emphasizing the initiation of scapular retraction in the early concentric phase and upright neck/thoracic postures in the inner motion range. Dynamic neck rotation exercises were performed against moderate rotatory resistance using elastic rubber bands (Theraband, Hygiene Corp., Akron, OH) in seated position. This exercise was intended to train co-contraction including flexor and extensor muscles. Holding the rubber band between the teeth and anchored between hands and a wall, the subjects first slightly nodded the head, extended the head slightly and then gently rotated it. Neck flexor isometric endurance was trained supine by first nodding the head and then lifting it a few centimeters from the surface against gravity (for 30 seconds or until perceived exertion was "strong", *i.e.*, 5 on the Borg CR-10 scale[24,25]). No high/maximal-load neck exercises were included, particularly since helicopter pilots with prior neck-pain, as opposed to fighter pilots, have shown altered myoelectric patterns rather than loss of neck strength.[10] Flying hours and exercise adherence were monitored in both groups using diaries.

Outcome Measures

Main outcome measures were change in the prevalence of neck pain during the previous week and 3 months, respectively, from baseline to end-point at the 12-month follow-up. Pain ratings were collected in a questionnaire for use with military pilots,[4,26] and any pain experience (pain, ache, discomfort) during the previous week and previous 3 months was elicited. The questions were originally derived from the Nordic Musculoskeletal Questionnaire.[27] Results were binary-coded (*i.e.*, any neck pain during the period defined, or pain-free), so defining a neck pain case or a pain-free subject.

Secondary outcomes included sternocleidomastoid electromyographic (EMG) activity during staged active craniocervical-flexion (details below) and pain-related fear as measured with the modified fear-avoidance beliefs questionnaire about physical activity (FABQ).[28,29] As with the original 16-item FABQ,[30] the 4-item modified FABQ domain was answered on a verbal scale from 0: "strongly disagree" to 6: "strongly agree" (score sum 0–24; higher score indicating greater pain-related fear). Eligible participants first completed these questionnaires, which were administered by independent assistants. The rationale for recording sternocleidomastoid activity was to obtain objective measurements of the participants' ability to relax their global surface neck-flexors during a standardized test of active craniocervical flexion, while data on fear avoidance were collected in order to monitor pain-related fear, particularly since such behavior may independently modulate muscle activity, as shown with EMG.[14]

Electromyography. Surface EMG was recorded bilaterally from the sternocleidomastoid, with electrodes overlying the lower third of the sternal muscle head as recommended[31] and previously measured in pilots.[10,25] After skin preparation according to SENIAM recommendations,[32] bipolar electrodes were applied with an center-to-center distance of 20 mm (Ag/AgCl, Blue-Sensor N-00-S, Medicotest A/S, Ølstykke, Denmark). With the participants supine, the knees bent and the head in a horizontal position,[33] active craniocervical flexion was performed at 5 isometric low-load pressure increment stages (22–24–26–28–30 mm Hg) controlled by an air-filled pressure sensor (Stabilizer, Chattanooga Group, Hixon, TM) placed behind the neck (same sensor as used in craniocervical flexion exercises). Each contraction lasted 10 seconds while myoelectric activity was sampled (10 seconds rest between stages). The signals were preamplified 1000 times, band-pass-filtered 20–500 Hz, and passed through a 12-bit A/D converter with a sampling frequency of 1 kHz (Mega-Win 2.0, Mega Electronics Ltd., Kuopio, Finland). Signals were quantified as root mean square (RMS [μV]) over 1 second for each of the five craniocervical-flexion stages and were normalized as the per-

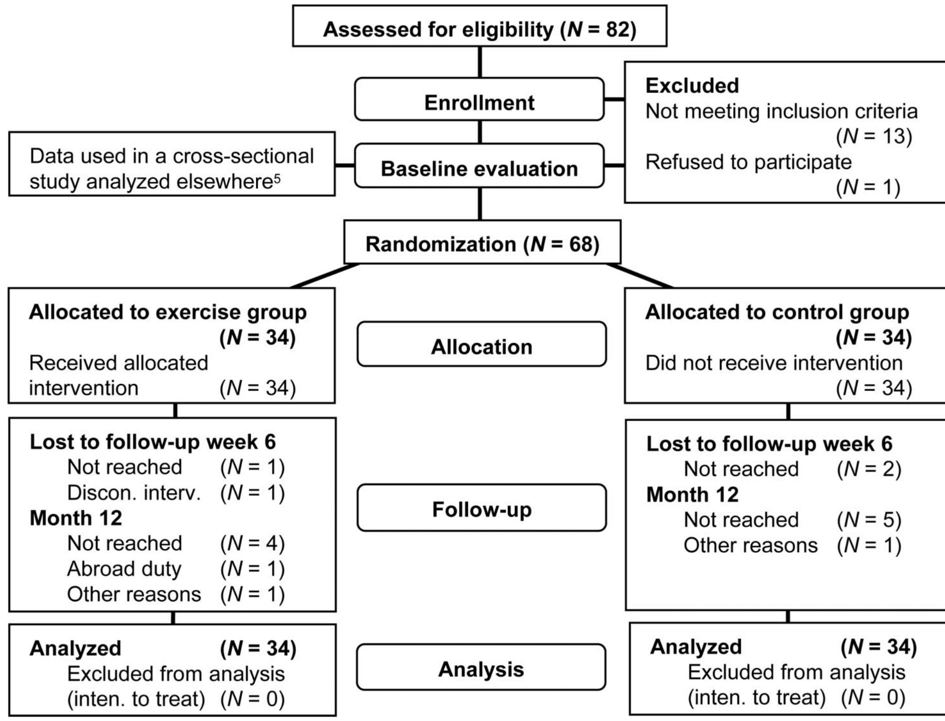

Figure 2. Participants' flow through the trial.

centage RMS of reference voluntary electricity (RVE) contraction against the weight of the head:

$$\text{Normalized RMS(nRMS } [\%\mu V]) = \text{RMS} \times \text{RVE}^{-1} \times 100$$

where RVE was the first RMS second of a head lift in supine.

Predictors in the Secondary Analysis

Analysis of potential preintervention predictors—as obtained at baseline—of change in the prevalence of neck-pain cases at 12 months follow-up included: sternocleidomastoid activity (nRMS), pain-related fear (FABQ), and reported muscle-strength training, fitness training, age, and flying hours during the past year as recorded in the questionnaire for use with military pilots. Muscle-strength training concerned strength training in any body part and fitness training concerned aerobic exercises such as running and cycling: these variables was expressed in hours per week.

Statistical Analysis

For the main outcome measure (the prevalence of neck-pain cases at month 12), an intention-to-treat procedure was followed (last-observation-carried-forward). Logistic regression was used to examine the effect of group (exercise group *vs.* controls) on change in the prevalence of neck-pain cases at month 12. Baseline proportion data on neck pain ratings were set as covariate.

Regarding secondary outcomes, a repeated-measures, mixed-model analysis of covariance was used to assess effects of the sternocleidomastoid-activity ($nRMS_{22-30}$)-variable domain. Fixed factors were group (exercise *vs.* control group), progression of pain (acute ongoing pain, subacute, and pain-free subjects during the previous 3 months); and stages of active craniocervical flexion, while subjects were the random factor. Acute ongoing pain was defined as the presence of neck pain at the time of testing (VAS >10 mm), while subacute pain was reported neck pain during the previous 3 months but no pain at the time of testing—as previously described.[5] Normality of data were enhanced by log transformation; mean nRMS of the left and right side was used.[5,34] Effect size Cohen's d aided clinical interpretation of the magnitude of treatment effect on EMG data, where effect-size values below 0.2 were considered small, 0.5 medium, and 0.8 large.[35] The nonparametric rank invariant method[36] was used for studying the within-group change in pain-related fear. This method is valid for ordered data without assumptions of data normality. As with the main outcome, an intention-to-treat procedure was followed. The change from baseline to each follow-up was expressed by the measure of systematic change in relative position ranged from −1 to 1.[36] A change towards a lower score after follow-up will result in a negative value of relative position. In addition, a dose-response regression analysis between exercise compliance and main and secondary outcomes at the six-week and 12-month follow-ups was conducted.

Predictors in the Secondary Analysis. Analysis of potential preintervention predictors of change in the prevalence of neck pain cases at the 12-month follow-up (sternocleidomastoid activity, pain-related fear, reported muscle-strength training, fitness training, age, and flying hours past year) were analyzed retrospectively with logistic regression. Significance was indicated at $P < 0.05$ for all analyses.

■ Results

Participants' recruitment and retention are summarized in Figure 2. Overall, 68 participants were assigned at random to exercise group or controls. Sixty-four (94%) completed the six- week follow-up period, and 56 (82%) provided data at month 12. Baseline characteristics for the randomized participants were similar (Table 1). Regression analyses on baseline values revealed no differences between participants included in intention-to-treat and those completing the tests. No complication associ-

Table 1. Baseline Demographic and Clinical Characteristics of Participants Assigned at Random to Exercise Group or Control Group

Characteristic	Exercise Group *N* = 34	Control Group *N* = 34
Age (yrs)	37.3 (6.4)	37.7 (5.4)
Height (m)	1.81 (0.04)	1.82 (0.06)
Weight (kg)	81.0 (6.3)	82.6 (9.9)
Exercise habits (h × wk^{-1})		
Fitness training	3.3 (1.5)	3.1 (1.3)
Muscle-strength training (range)	1.0 (0–4.0)	0.9 (0–3.0)
Total flying time (h)	1989 (916)	2209 (1180)
Months since first neck pain episode (range)	47 (1–190)	49 (5–120)

Values are mean (SD) unless otherwise indicated.

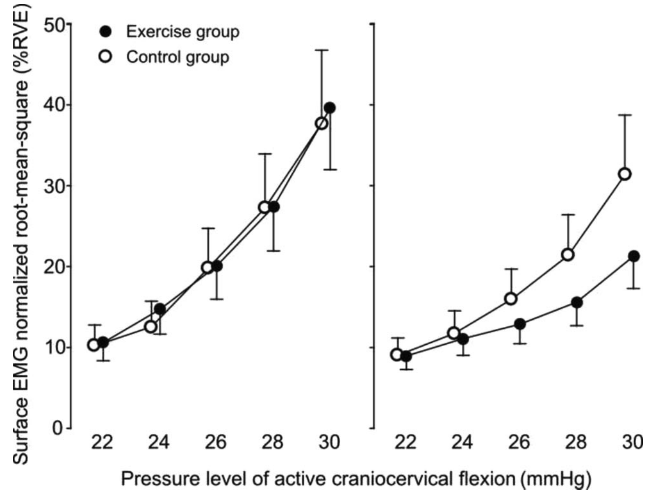

Figure 3. Electromyographic activity of sternocleidomastoid muscles during the craniocervical flexion test. At each stage of the test, pressure (22–30 mm Hg) was monitored from an air-filled sensor placed suboccipitally behind the neck. Geometric means and 95% confidence intervals of normalized root-mean-square values. Graphs illustrate muscle activity at baseline (left) and at the 6-week follow-up (right) in control group and intervention group.

ated with the intervention was reported. Overall mean compliance with the prescribed daily regimen was 77% (71%–83%), given as median (25th–75th percentile).

Results of Main Outcome

Table 2 shows the change in the prevalence of neck pain cases from baseline to month 12. In the exercise group, the prevalence of cases for the previous week and the previous 3 months decreased from 38% to 15% and 76% to 44%, respectively, whereas in controls it was unchanged. Between-group regression analyses revealed that the members of the exercising group had a 3.2 times greater chance (odds ratio) than the control group of having been pain-free during the previous 7 days and a 1.9 times greater chance (odds ratio) of having been pain-free during the previous 3 months, $P = 0.01$. There was no confounding from change in flying hours, general muscle-strength training or fitness training, all at $P > 0.25$.

Results of Secondary Outcomes

Figure 3 presents mean course of $nRMS_{22–30}$ values. Analysis of reference RMS data as obtained during head lift in supine showed no group differences through the data set, and the assumption of homogeneity of group covariance matrices on nRMS-data were not violated. Using score from pain-related fear as covariate, an interaction effect emerged for follow-up × group × nRMS stages ($P = 0.01$). There were no additional effects for subgroups with different progressions of pain. *Post hoc* analyses showed that at week six the exercise members had significantly decreased $nRMS_{30}$ sternocleidomastoid activity as compared to controls ($P = 0.01$; effect size = 0.70). In addition, there was a trend towards reduction in $nRMS_{28}$ ($P = 0.07$; effect size = 0.51). There was however, no effect for lower stages ($nRMS_{22–26}$: $P = 0.21–0.79$; effect size = 0.35–0.02).

A dose-response regression analysis between exercise compliance and EMG change from baseline to the six-week follow-up was negative for all pressure stages ($nRMS_{22–30}$), indicating that the greater the compliance the greater the reduction in sternocleidomastoid activity. However, there was no such trend for either reduction in cases or for fear-avoidance beliefs at the 12-month fol-

Table 2. Prevalence of Neck-Pain Cases at Baseline and Month 12 (End-Point) and Effect of Group (Exercise Group, *N* = 34 *vs.* Control Group, *N* = 34) of Exercise Intervention on Neck-Pain Ratings at Month 12

				Between-Group Effect*		
				Logistic Regression		
Outcome Group	Baseline	Month 12	Improved/ New Case	OR	95% CI	*P*
Prevalence of neck pain during previous week						
Controls, *N* (%)	11 (32)	11 (32)	6/6	1†		
Exercise, *N* (%)	13 (38)	5 (15)	11/3	3.2	1.3–7.8	0.013
Prevalence of neck pain during previous 3 months						
Controls, *N* (%)	21 (62)	21 (62)	5/5	1†		
Exercise, *N* (%)	26 (76)	15 (44)	14/3	1.9	1.2–3.2	0.008

Odds ratio (OR), 95% confidence interval (CI).
*Baseline proportion data were set as covariate.
†Reference category.

Table 3. Median (Min–Max) Scores of Pain-Related Fear About Physical Activity (mFABQ: Score Range 0–24, Higher Score Indicates Greater Pain-Related Fear) at Baseline, Week 6 and Month 12 and Effect of Group (Within- and Between-Group Effect). Exercise Group (*N* = 34) and Control Group (*N* = 34)

Pain-Related Fear	Group	Baseline	Week 6	Month 12
mFABQ	Controls	6.5 (0–18)	3.5 (0–18)	5.5 (0–21)
	RP (SE)		−0.196 (0.08)*	−0.103 (SE 0.10)
	Exercise	6.0 (0–17)	1.0 (0–20)	1.5 (0–17)
	RP (SE)		−0.238 (0.08)†	−0.231 (0.10)*
	Between-group effect		NS	NS

RP: systematic change in relative position, within-group effect (non-parametric rank invariant method).
*$P < 0.05$; †$P < 0.01$.

low-up. In addition, EMG change from baseline to the 6-week follow-up was traced using results for cases at the 12-month follow-up. Clustering all 68 subjects (exercise and controls together), cases that improved, *i.e.*, pilots that rated neck pain at baseline but not at the 12-month follow-up, reduced their $nRMS_{22–30}$ by on average 36%, while other subjects reduced theirs by 25%.

Regarding pain-related fear, Table 3 shows the median (range) and the systematic disagreement in relative position from baseline to 6-week and 12-month follow-ups, respectively. In the exercise group, a reduction from baseline to week-6 was apparent ($P = 0.01$), whereas baseline-to-month-12 was somewhat less significant ($P = 0.03$). However, in controls, a reduction from baseline was indicated at week six ($P = 0.03$); although not at month 12 ($P = 0.35$). The Mann-Whitney U test revealed no between-group differences at week 6 ($P = 0.52$), nor at month 12 ($P = 0.26$).

Results of Predictors in the Secondary Analysis

In the exercise group, analysis of early predictors of reduction in neck-pain cases at the 12-month follow-up showed that general muscle-strength training for more than one hour per week at the time of study allocation was related to reduction in neck-pain prevalence for the previous 3 months ($P = 0.05$). This was however, not significant for pain prevalence the previous week. No significant preintervention predictor appeared for controls.

Discussion

This trial indicated that the present neck/shoulder exercise regimen was effective in reducing the prevalence of neck-pain cases in air force helicopter pilots on duty. The pilots following the regimen exhibited reduced sternocleidomastoid activity postintervention as observed at higher contraction levels of craniocervical flexion. However, no effect emerged for pain-related fear.

The present cohort was considered to be a representative helicopter-pilot sample, with similar demographics to those from other studies.[3,4,37] Since the study targeted problems of prevention, the external relevance extends to pilots on duty rather than to subjects seeking care. Analyzing change in the prevalence of neck-pain cases, *i.e.*, tracing cases/pain-free pilots who improved or became cases at a 12-month follow-up, may appear nonsensitive to change. However, we opted to investigate this as defined since we learned that pilots with recurrent episodes of neck pain, rather than rated pain intensity at a certain time, constitute the actual problem in this population. As far as practically possible, we endeavored to follow recommendations for methodologic quality in clinical trials.[38–40] The intervention was based on evidence from the general population[11,40–43] and clinical experience and evidence from a series of studies of helicopter pilots.[4–7,10,25] While the exercises were expected to be performed relatively often, they were considered to be time-effective and required no advanced equipment. Importantly, regimen compliance at 77% was considered acceptable, making it a realistic intervention option in this population.

The regimen was considered effective over 12 months, significant for reduction in cases for the previous week and previous 3 months, respectively. Future studies analyzing consequences of such regimens on pilots' activities and participation should be conducted on a larger sample. The favorable results in the exercise group are consistent with other randomized trials investigating the efficacy of muscle control exercises in subjects with neck pain[43,44] and cervicogenic headache.[42,45]

In the exercising group, clear reduction of sternocleidomastoid EMG activity under active craniocervical-flexion was seen only when the highest muscle force was exerted. Although several studies have shown increased surface-EMG activity in subjects with pain,[8,11] we have found few trials investigating whether exercise may reduce such activity. The present reduction in highest-pressure stages may reflect adaptational improvement in neck-flexor motor synergies rather than reduction in sternocleidomastoid hyperactivity. Hypothetically, such more accurate neck-muscle recruitment may increase endurance time for perceived neck-muscle fatigue or pain during flight. However, it is unclear whether the reduction shown transfers to other posturally-dependent situations. This needs more study. In addition, there were no effects for subgroups with different progressions of pain. Such subanalysis may however, be violated from lack of power and, with respect to type II error, should not exclude the possibility of differences between acute and subacute neck-pain sufferers. In support of this, however, cases that improved, *i.e.*, rated neck pain at baseline but not at the 12-month follow-up, related somewhat greater reduction in sternocleidomastoid activity ($nRMS_{22–30}$) as observed at the 6-week follow-up. Future studies of larger samples may usefully run more sophisticated analyses to find out whether postintervention intermediate changes match long-term outcome results.

Our dose-response analysis indicated that greater reduction in sternocleidomastoid activity was linked to greater compliance with the intervention. This suggests that daily (or more) exercising is important for reduction in aberrant surface neck-muscle activity.

Pain-related fear about physical activity was somewhat reduced, but no between-group differences emerged. Fear of movement may be justified in the acute stage of pain, *i.e.*, to prevent further amplification of pain and painful muscles.[15] However, such beliefs seem also to predict future pain episodes[29] and may induce changes in physical activity and modulate muscle activity as shown by EMG.[14,46] The lack of significant between-group differences should be interpreted in the context that participants were enrolled from the population, rather than from clinics; and that our pilots had low initial scores as compared to what is observed in the general population.[28,29,47] The observed effect in our control group may reflect the attention from the research team, including encouragement by medical personnel to continue with ordinary training.

Our secondary analysis of early predictors showed that only general muscle-strength training for more than one hour per week indicted a predictive value for reduction in cases that, at the 12-month follow-up, reported pain during the previous 3 months. There was thus no association between baseline measures of sternocleidomastoid activity and the 12-month follow-up, or for fear, fitness training, age, or flying hours. However, our findings support previous findings that muscle-strength training for more than one hour per week may be a health indicator in helicopter pilots with bouts of neck pain.[4] Perhaps pilots who perform strength training more regularly could more efficiently incorporate the regimen with their daily routine.

While further studies are required to clarify mechanisms related to the present results, taken as a whole the present intervention can, we believe, be considered as a prevention strategy for military pilots. This is particularly so since neck-pain cases were reduced, the exercises were relatively easy to conduct with acceptable compliance, and no complication was reported because of the intervention. Importantly, the regimen was not intended for use in isolation; it may be used/incorporated with general strength training, possibly with other training items as well.

Conclusion

In this trial, a supervised neck/shoulder exercise regimen was considered effective over a 12-month period for reducing the prevalence of neck pain in air force pilots. The reduced sternocleidomastoid activity in an isometric craniocervical-flexion test may indicate improved neck-muscle synergy, although it is unclear whether this finding applies to other functional tasks: this should be further studied. Although a within-group effect emerged for pain-related fear about physical activity, there were no differences between the exercise group and controls. General muscle-strength training was related to reduction in cases, possible indicating that pilots performing such training could more efficiently incorporate the regimen with their ordinary activities.

Key Points

- A randomized controlled trial investigated the preventive efficacy of a six-week neck/shoulder exercise regimen as compared to no regimen in air force helicopter pilots on active duty. This population frequently experiences neck pain related to flying.
- At a follow-up after 12 months, results showed a reduction in neck pain cases in participants allocated to the regimen.
- Neck-flexor motor function improved as observed with electromyography. No effect emerged for pain-related fear about physical activity.
- Preintervention general muscle-strength training for more than one hour per week was indicated as a predictor of the reduction in cases.
- The present exercise regimen appears to have a positive preventive effect, and was considered a realistic option in this population.

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