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Resistance Band Exercise Regimen Effects on Cervical Spine Range of Motion, Strength, And Muscular Control

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14. ABSTRACT

Recent reviews of the Defense Medical Surveillance System database show intervertebral disc and cervical spine disorders among the top ten ambulatory diagnoses for all military services. Furthermore, reports show that neck pain is even more prevalent (43-48%) in rotary-wing pilots within the U.S. military. Approximately 20% of U.S. military rotary-wing pilots with neck pain experienced regular or continuous pain. Increasing cervical spine strength has been shown to decrease neck pain in clinical settings and improve muscle performance in aviators. This study conducted a series of prospective trial interventions to determine the effects of cervical spine directed resistance band exercises on cervical spine strength, range of motion, and control in military aviators. Subjects performed five resistance band exercises for two sets of 10-15 repetitions once a day, five days a week, for six weeks. Cervical spine range of motion (CROM) increased significantly in all measured planes. Isometric strength increased for both flexion and extension, but only extension was found to be significant. Muscular control for both flexion and extension increased significantly. The findings of this study demonstrate that a cervical spine directed resistance band exercise regimen is an effective method for increasing CROM, isometric strength, and muscular control, which may reduce pain.

15. SUBJECT TERMS

cervical spine, resistance band, exercise, neck strength, CROM, range of motion, rotary wing, aviators, IBPG

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Summary

The North Atlantic Treaty Organization Human Factors and Medicine Research Task Group Panel 252 (NATO HFM RTG-252) was approved in December 2013 to address the issue of aircrew neck pain prevention and management in military populations.

As members of the NATO HFM RTG-252 panel, the U.S. Army Aeromedical Research Laboratory (USAARL), in conjunction with the U.S. Naval Air Warfare Center Aircraft Division (NAWCAD), examined the effects of a progressive six-week cervical spine-directed resistance band exercise regimen on cervical spine range of motion, isometric strength, and muscular control.

Subjects performed five resistance band exercises for two sets of 10-15 repetitions once a day, five days a week, for six weeks. The cervical spine range of motion (CROM) increased significantly in all measured planes. Isometric strength increased for both flexion and extension, but only extension was found to be statistically significant. Muscular control for both flexion and extension increased significantly. The findings of this study demonstrate that this cervical spine-directed resistance band exercise regimen is an effective training method for increasing CROM, isometric strength, and muscular control. Future work will leverage these findings to develop and incorporate operationally-specific training and treatment interventions to optimize Soldier performance.

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Introduction

In the general population, neck pain has been associated with advanced age, previous pain episodes, pain in other regions of the body, psychological factors, and vocational factors (Äng & Harms-Ringdahl, 2006). Neck pain had a point prevalence of 4.9% and ranked 4th in terms of "years lost to disability" in a recent survey of global disease (Hoy et al., 2014). The prevalence of neck pain is even greater within the U.S. Military, with recent reviews of the Defense Medical Surveillance System (DMSS) database showing intervertebral disc and cervical spine disorders among the top ten ambulatory diagnoses for all military services. Furthermore, reports show that neck pain is even more prevalent (43-48%) in rotary-wing pilots within the U.S. Military, of which approximately 20% experienced recurring or continuous neck pain (Van den Oord et al., 2010; Bridger et al., 2002).

Considerable research has been conducted on exposure limits for Soldiers wearing increased head-supported mass (HSM) because of its potential to impact health, readiness, and performance (LaFiandra et al., 2007; Madison, 2019; Fraser et al., 2006; Butler & Alem, 1997; Alem et al., 1995). The increased stress placed on the cervical spine can lead to a rapid onset of musculoskeletal fatigue, pain, and potential long-term degenerative changes (Froom et al., 1984; Hamalainen et al., 1999; Hamalainen et al., 1996; Landau et al., 2006; Pippig & Kriebel, 2000). As a result, research aims have generally focused on acute (e.g., crash-related) injury exposure, computer modeling of neck anatomy and injury mechanisms, and performance decrement risk. While limiting exposure to increased HSM by specifying allowable helmet weight and center of mass is useful to system developers, medical personnel need better guidance regarding operational prevention techniques and various treatment options for neck pain and injury in aviators.

Preventive strategies for neck injury relevant to the operational aviation environment include training and equipment countermeasures. Training countermeasures may include neck exercise or flexibility programs, while equipment countermeasures could include cervical braces or collars that are intended to off-load HSM from the neck. Although there have been published studies examining these strategies (e.g., Äng et al., 2006; Berg et al., 1994; Hämäläinen et al., 1998; Alricsson et al., 2004; Burnett et al., 2005; Nagai et al., 2014), there are conflicting data concerning the protective nature of exercise, no standardized training regimen, no adopted guidelines, and limited awareness of these studies or the remaining research gaps.

Participation in a supervised neck and shoulder exercise regimen has proven effective in reducing the prevalence of neck pain cases in operational helicopter pilots (Äng et al., 2006). However, reduced sternocleidomastoid muscle (i.e., neck flexor) activity was reported. Increasing cervical spine musculature strength has been shown to decrease neck pain in clinical settings (Berg et al., 1994) and improve muscle performance in aviators (Hämäläinen et al., 1998; Alricsson et al., 2004). Previous studies on cervical spine-directed exercise regimens do not include rotational loading and generally start from a neutral position (Burnett et al., 2005), which fails to incorporate the full musculature range of motion. Reports have shown reduced cervical spine range of motion (CROM) in patients with a history of neck pain, especially in extension and rotation (Nagai et al., 2014); however, CROM is not commonly reported in cervical spine-directed exercise regimens (Bennett et al., 2002; Burnett et al., 2005; Nagai et al., 2014, Äng, et al. 2006; Highland et al., 1992; Geary et al., 2014; Conley et at., 1997; Ylinen et

al., 2006; Leggett et al., 1991; Murray et al., 2017; Falla et al., 2007; Hyrsomallis, 2016; Harrison et al., 2016; Thuresson et al., 2003; Häkkinen & Komi, 1983; Moritani & de Vries., 1979; De Luca & Contessa, 2015; Hill et al., 2016; Smith, 2016; Basmajian & De Luca, 1985; Smith et al., 2017; Jenkins et al., 2015a; Jenkins et al., 2015b).

Because aviator neck pain is a well-documented problem with an international scope, the North Atlantic Treaty Organization Human Factors and Medicine Research Task Group Panel 252 (NATO HFM RTG-252) was approved in December 2013 to address aircrew neck pain prevention and management in military populations. The overall objective of the panel is to seek creative administrative, procedural, and preventive, as well as ergonomic and engineering, solutions for reducing neck pain that were presented as recommendations in the Research Task Group's final report. NATO HFM RTG-252 has taken a multi-disciplinary approach that involves engineers, human system integration and ergonomics specialists, physiologists, medical officers, physiotherapists, helmet manufacturers, and operators. To meet the group panel aim, several member countries agreed to implement a version of an exercise regimen that leverages the results of the study and targeted exercise program conducted by Äng, et al. (2006) and addresses additional research gaps.

As members of the NATO HFM RTG-252 panel, the U.S. Army Aeromedical Research Laboratory (USAARL), in conjunction with the U.S. Naval Air Warfare Center Aircraft Division (NAWCAD), examined the effects of a progressive six-week cervical spine-directed resistance band exercise regimen on cervical spine range of motion, isometric strength, and muscular control. The end goal of the study is a demonstrated effective exercise program that can be implemented by U.S. Army operational units for neck pain prevention and treatment. Additionally, study outcomes can facilitate informed decisions about potential prevention and mitigation strategies within both military and civilian populations.

Methods and Materials

U.S. Army Flight School (Fort Rucker, AL) students and instructor pilots were recruited and consented under a protocol approved through Naval Air Warfare Center Aircraft Division Institutional Review Board (NAWCAD IRB). A site-specific protocol addendum was implemented to allow the study to be replicated and conducted at Fort Rucker. Because Fort Rucker has a principal function as the U.S. Army's center for helicopters, this enabled the study to reach a wider population and include a larger demographic range. Additional inclusion criteria required participants to be physically able to complete all exercises and be available for pre-, mid-, and post-training assessments. Those who had previous neck surgeries, neurologic symptoms, serious back pain, or participated in a neck-training program within the last twelve months were ineligible to participate.

Potential participants were medically screened before enrollment in the study. Baseline fitness, description of any current neck pain, age, anthropometry, flight hours, occupational data, CROM, and cervical spine muscular strength were determined (Appendix B). Volunteers were randomly assigned to control and exercise study groups.

A series of prospective, controlled trial interventions were conducted to determine the effects of a cervical spine-directed resistance band exercise regimen on cervical spine strength, range of motion, and control in military aviators. Subjects performed five resistance band exercises for two sets of 10-15 repetitions at progressing resistance levels (Table 1). The resistance band exercises (protraction/retraction, flexion, extension, left/right lateral flexion, and left/right rotation) were conducted daily, five days a week, for six weeks using the NeckX® (Appendix C; Neck X LLC, Aspen, CO). Each exercise repetition was completed through full CROM as a cyclic 2-second stretch, 4-second concentric contraction, 2-second isometric contraction, and 4-second eccentric series. Subjects performed the training regimen at their own volition; however, along with the assessment visits, a weekly in-person/virtual checkup was conducted to provide any necessary exercise technique corrections, ensure training compliance, and keep the subject engaged in the study. Weekly logs were collected to capture flight hours, neck pain related or unrelated to flying, treatments, study exercises, and other physical activities.

Table 1. Exercise Training Matrix

Week	Resistance Band Level	Sets	Repetitions
1	Low	2	10
2	Medium	2	10
3	High	2	10
4	High	2	15
5	High	2	15
6	High	2	15

Note. Progressive six-week cervical spine-directed resistance band exercise training regimen performed for the exercises: protraction/retraction, flexion, extension, left/right lateral flexion, and left/right rotation.

Subjects completed pre- (week 0), mid- (week 3), and post-training (week 6) CROM, dynamometer, and exercise repetition assessments. Subjects completed a 5-10 minute cervical spine-directed warmup to begin each test day, followed by the CROM, dynamometer, and exercise repetition assessments (Figure 1). Following the CROM assessment, subjects were instrumented with six Delsys Trigno Mini (Figure 2) wireless electromyography (EMG) sensors placed bilaterally in the area of the upper trapezius (extensor), splenius capitis (rotator), and sternocleidomastoid (flexor) muscles. Prior to electrode placement, the surface of the skin was shaved, if necessary, then lightly abraded and cleaned with alcohol wipes.

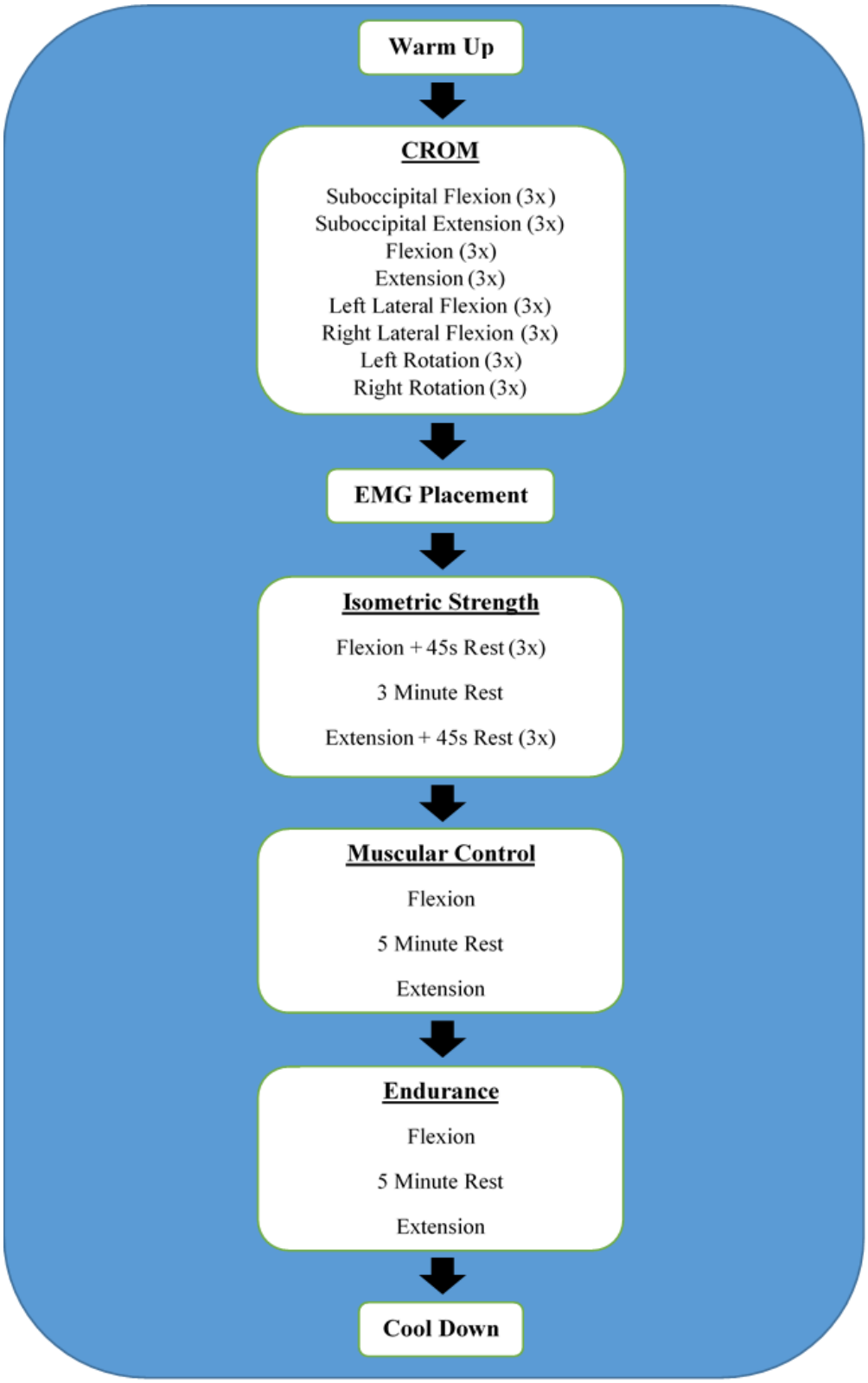

Figure 1. Assessment order. Assessments were consistently conducted and collected in the same order during all pre-, mid-, and post-training subject visits.

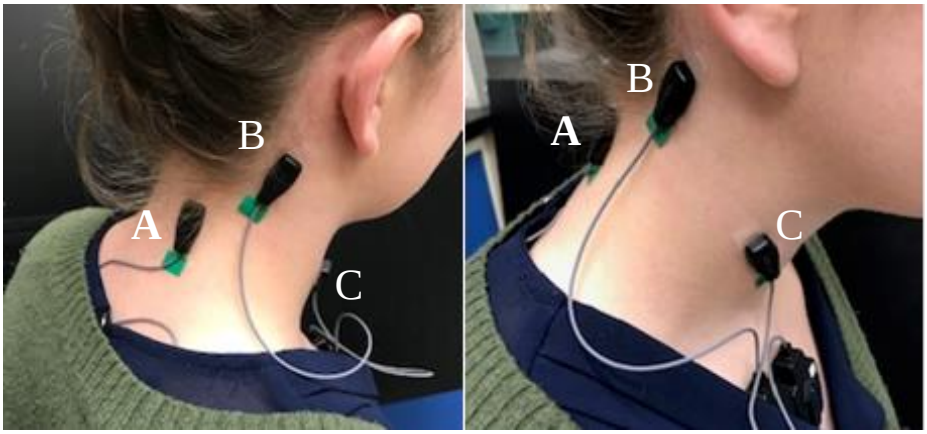

Figure 2. Delsys Trigno Mini placement. Six Delsys Trigno Mini electromyography (EMG) sensors were placed bilaterally on the A) upper trapezius (extensor), B) splenius capitis (rotator), and C) sternocleidomastoid (flexor) to record the electrical activity of the respective muscles during dynamometer and exercise repetition assessments.

Cervical Range of Motion (CROM) Assessment

CROM measurements were taken using the CROM device (Performance Attainment Associates, Lindstrom, MN) (Figure 3). The device has been validated and proven accurate for clinical CROM measurements in the cervical spine with good inter-tester and intra-tester reliability (Youdas et al., 1991; Rheault et al., 1992). Each subject was instructed and trained on the function and procedure of the CROM assessment prior to data collection. Three repetitions of each motion were performed and recorded before conducting the next motion. Measurements collected: sub-occipital flexion/extension, flexion, extension, left/right lateral flexion, and left/right rotation.

Figure 3. Illustration of CROM device and use. The CROM device was used to conduct and collect all CROM measurements: sub-occipital flexion/extension, flexion, extension, left/right lateral flexion, and left/right rotation.

Dynamometer Assessment

Isometric strength, muscular control, and endurance measurements were collected using the BTE Primus RS dynamometer (BTE, Hanover, MD) (Figure 4) in coordination with a custom-built MATLAB (MathWorks, Natick, MA) software program (Figure 5). Subjects were seated upright and secured in an affixed chair via shoulder, lap, and chest harness straps. The chair and dynamometer were set to position the subject's head in the neutral position for all assessments. Performance feedback was provided to the subject during muscular control and endurance assessments via a television screen. Each subject was instructed and trained on the function and procedure of the dynamometer assessments on a day prior to data collection. Subjects first completed isometric strength in flexion and extension, followed by muscular control, then endurance tasks.

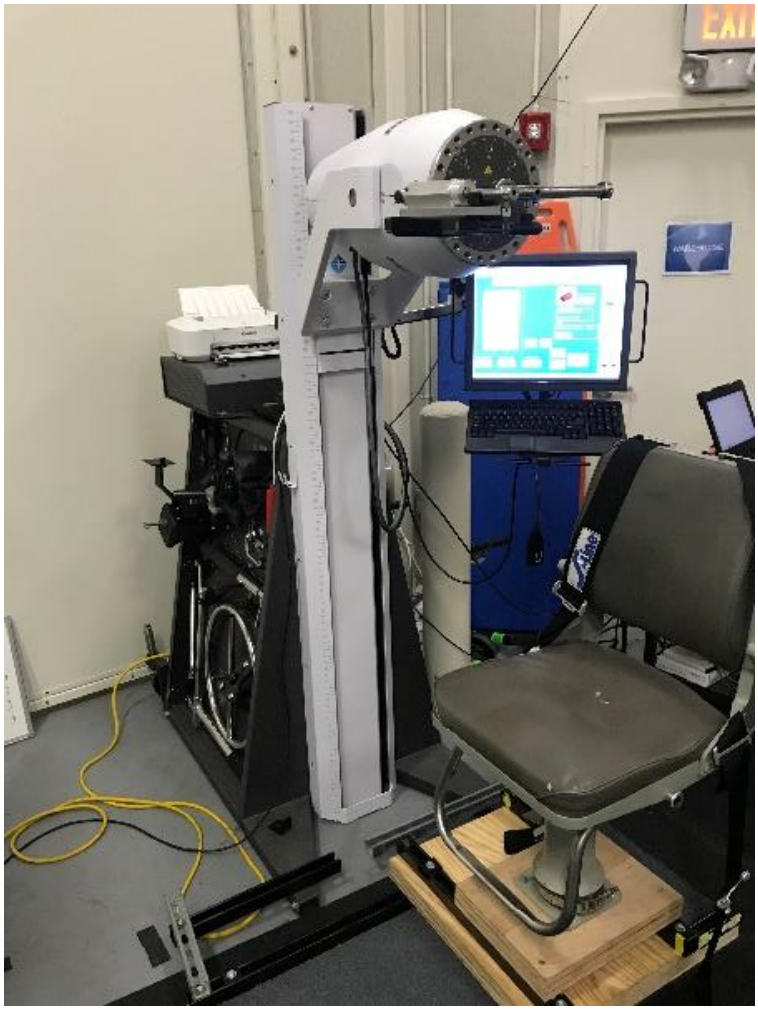

Figure 4. Dynomometer. The BTE PrimusRS with affixed chair used in conjunction with the custom-built MATLAB graphical user interface (GUI) to conduct and collect the dynamometer assessments (isometric strength, muscular control, and endurance).

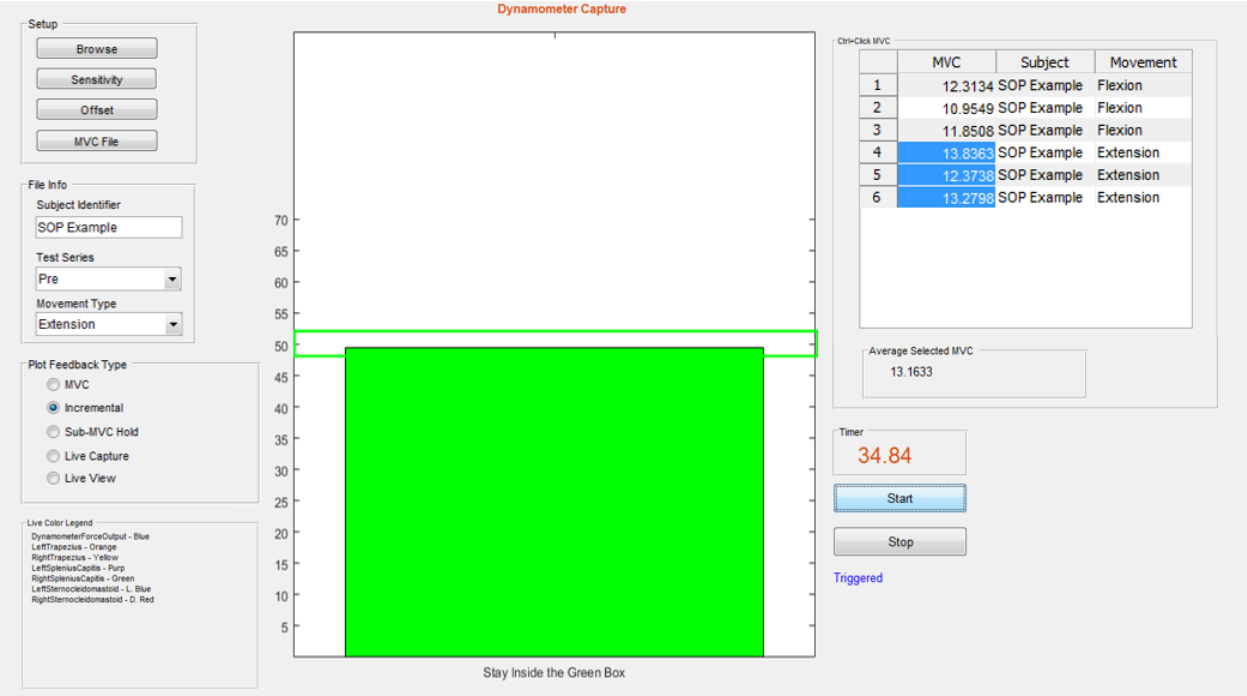

Figure 5. Custom-developed MATLAB GUI. Custom-developed MATLAB GUI was used, in conjunction with the BTE PrimusRS to conduct and collect dynamometer assessments. Muscular control task in extension is shown here as an example.

Isometric strength (Newtons).

Subjects completed three 4-second isometric maximal voluntary contractions (IMVC) for flexion and extension. Forty-five seconds of rest was given between each trial, with three minutes of rest between directions and five minutes of rest after.

Muscular control (% Time on Target).

The three IMVC trials were used to determine an average IMVC for flexion and extension for each subject. Subjects were tasked with producing incremental targeted force output from 5% to 70% of their average IMVC in ascending and descending order in 5% increments for 2 seconds per increment with 5 minutes of rest between directions and after.

Endurance.

For the purposes of this publication, endurance assessment results are to be reported separately.

Exercise Repetitions Assessment

The maximum number of repetitions possible while using proper technique at a preset resistance for flexion, extension, left/right lateral flexion, and left/right rotation was determined while initially grasping the bands with their arms placed at an upright 90 degrees. Immediately upon completion of exercises, subjects were asked subjective questions to rate their impression

of their neck flexibility, strength, stiffness, and pain after on a 4-point scale (1-Worse, 2-Same, 3-Slightly Improved, 4-Greatly Improved) compared to before they started conducting the training regimen.

Statistical Analyses

All statistical analyses were performed using R Package (Version 3.6.1). Descriptive statistics, including ranges, means, medians, standard deviations, standard errors of the mean, and minimum and maximum values, was calculated for all variables. An alpha of $p \leq 0.05$ was considered statistically significant for all statistical analyses.

One-way ANOVAs were performed to compare pre-, mid-, and post-training differences in CROM (degrees), isometric strength (Newtons), muscular control (% time on target), exercise repetitions (repetition performed to fatigue), and subjective questions (flexibility, strength, stiffness, and pain) for all test combinations of muscles (trapezius, splenius capitis, and sternocleidomastoid) and movement (flexion and extension). Tukey's Post-Hoc analysis was performed when appropriate for statistically significant ANOVA results.

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Results

Subject Demographics

Subject demographics are presented in Table 2. A total of 17 subjects were recruited and enrolled for participation. All subjects were enrolled in the exercise group to preserve effect size due to low recruitment numbers. Data from 12 subjects were analyzed; all subjects reported full adherence to the prescribed exercise regimen. Data from five subjects were incomplete due to study dropout and were excluded from this analysis. All subjects were enrolled in the exercise group to preserve effect size due to low recruitment numbers; thus, all data analyzed were obtained from subjects enrolled in the exercise group.

Table 2. Subject Demographics

Age (years)	27.3 (±4.2)
Mass (kg)	83.2 (±7.6)
Height (cm)	176.8 (±6.1)
Head Circumference (cm)	57.9 (±1.6)
Head Breadth (cm)	15.6 (±0.5)
Neck Circumference-Mid (cm)	38.9 (±1.7)
Neck Circumference-Base (cm)	41.0 (±2.2)
Neck Length (cm)	10.8 (±1.4)
Sitting Height (cm)	93.4 (±3.4)
Flight Time Prior Intervention (hours)	261.3 (±349.9)
Flight Time During Intervention (hours)	19.2 (±17.6)

Note. Mean (SD) values for subject demographics (N = 12) from U.S. Army Flight School students and instructor pilots enrolled in six-week progressive cervical spine directed resistance band exercise regimen group.

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CROM Assessment

The CROM values (degrees) are presented in Table 3. A statistically significant ($p < 0.05$) difference was found for all eight CROM measurements between pre- and post-training, with all except extension and right lateral flexion being statistically different from pre- to mid-training.

Table 3. CROM Results

Dependent Variables	Assessments (*N*=12)		
	Pre (0 Weeks)	**Mid (3 Weeks)**	**Post (6 Weeks)**
Suboccipital Flexion	8.8º (±2.7)	11.3º (±2.9)*	14.0º (±3.9)*
Suboccipital Extension	27.8º (±7.5)	33.3º (±5.1)*	35.8º (±7.4)*
Flexion	52.8º (±7.9)	62.1º (±5.8)*	62.4º (±9.3)*
Extension	60.7º (±7.5)	63.9º (±7.1)	66.8º (±6.4)*
Left Lateral Flexion	38.3º (±7.3)	43.3º (±7.2)*	47.6º (±7.2)*
Right Lateral Flexion	37.0º (±7.4)	40.7º (±5.5)	44.2º (±6.5)*
Left Rotation	61.9º (±6.2)	69.1º (±5.8)*	72.8º (±4.2)*
Right Rotation	64.5º (±5.8)	69.1º (±6.2)*	70.9º (±4.5)*

*****Statistically significant difference from pre-training
Note. Mean (SD) values for CROM (degrees) from U.S. Army Flight School students and instructor pilots enrolled in six-week progressive cervical spine directed resistance band exercise regimen group measured pre-, mid-, and post-training.

Dynamometer Assessment

Isometric strength.

Results for isometric strength reported in Newtons (N) are presented in Table 4. No statistically significant differences were found for isometric strength in flexion measurements. A statistically significant ($p < 0.05$) difference was found for isometric strength in extension between pre- and post-training measurements.

Table 4. Isometric Strength Results

Dependent Variables	Assessments (*N*=12)		
	Pre (0 Weeks)	**Mid (3 Weeks)**	**Post (6 Weeks)**
Flexion	145.5 N (±55.6)	158.7 N (±45.2)	170.8 N (±54.3)
Extension	167.3 N (±63.6)	195.2 N (±63.2)	219.4 N (±70.3)*

*****Statistically significant difference from pre-training
Note. Mean (SD) values for isometric strength (Newtons) from U.S. Army Flight School students and instructor pilots enrolled in six-week progressive cervical spine directed resistance band exercise regimen group measured pre-, mid-, and post-training.

Muscular control.

Results for muscular control (% of the time on target) are presented in Table 5. A statistically significant ($p < 0.05$) difference was found for both incremental targeted-force output measurements pre- and post-training, with flexion also being statistically different from pre- to mid-training.

Table 5. Muscular Control Results

Dependent Variables	Assessments (*N*=12)		
	Pre (0 Weeks)	**Mid (3 Weeks)**	**Post (6 Weeks)**
Flexion	59.9% (±6.5)	63.5% (±7.1)*	71.4% (±5.8)*
Extension	64.5% (±6.2)	68.4% (±4.3)	71.2% (±5.7)*

*****Statistically significant difference from pre-training
Note. Mean (SD) values for muscular control (% of time on target) from U.S. Army Flight School students and instructor pilots enrolled in six-week progressive cervical spine directed resistance band exercise regimen group measured pre-, mid-, and post-training.

Exercise Repetitions Assessment

Exercise repetitions.

Results for Exercise Repetitions (repetitions completed) are presented in Table 6. A statistically significant ($p < 0.05$) difference was found for all exercise directions measured, except extension pre- to post-training.

Table 6. Exercise Repetition Assessment

Dependent Variables	**Assessments (*N*=12)**		
	Pre (0 Weeks)	**Mid (3 Weeks)**	**Post (6 Weeks)**
Flexion	7.9 (±3.9)	10.8 (±3.0)	12.2 (±3.5)*
Extension	10.8 (±5.3)	14.6 (±5.9)	16.4 (±5.4)
Left Lateral Flexion	6.8 (±3.2)	9.2 (±3.4)	10.9 (±3.2)*
Right Lateral Flexion	6.7 (±3.3)	9.4 (±3.5)	10.9 (±3.3)*
Left Rotation	7.1 (±2.3)	9.6 (±2.7)	11.7 (±3.8)*
Right Rotation	7.3 (±2.9)	9.7 (±3.1)	11..5 (±3.8)*

*****Statistical Significant Difference from Pre-Training
Note. Mean (SD) values for Exercise Repetitions (repetitions completed) from U.S. Army Flight School students and instructor pilots enrolled in six-week progressive cervical spine directed resistance band exercise regimen group measured Pre-, Mid-, and Post-Training.

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Subjective Questions

Mean (SD) for Subject Questions (4-point scale: 1-Worse, 2-Same, 3-Slightly Improved, 4-Greatly Improved) are represented in Table 7. A statistically significant ($p < 0.05$) difference was found for flexibility as self-reported at the mid- and post-assessments, and strength and stiffness as self-reported only at the post-assessment. For self-reported pain, there was no statistically significant difference found between any combination of the pre-, mid-, or post-assessments.

Table 7. Subjective Questions

Dependent Variables	**Assessments (*N*=12)**		
	Pre (0 Weeks)	**Mid (3 Weeks)**	**Post (6 Weeks)**
Flexibility	2.0 (±0.0)	2.8 (±0.6)*	2.9 (±.8)*
Strength	2.0 (±0.0)	2.3 (±0.6)	2.8 (±0.7)*
Stiffness	2.0 (±0.0)	2.4 (±0.5)	2.5 (±0.6)*
Pain	2.0 (±0.0)	2.4 (±0.6)	2.2 (±0.4)

*****Statistically significant difference from pre-training
Note. Mean (SD) values for subjective questions (4-point scale: 1-Worse, 2-Same, 3-Slightly Improved, 4-Greatly Improved) measured pre-, mid-, and post-Training.

Discussion

Overall, the findings of this study show that a six-week progressive resistance band cervical-spine directed exercise regimen can improve cervical spine strength, range of motion, and muscular control in a healthy aviator population. The resistance band regimen allowed subjects to self-select and self-apply the desired level of resistance, minimizing the risk of injury. The prescribed exercise regimen was well-received; subjects reported improved strength, flexibility, and stiffness after the six-week intervention while adhering to the take-home regimen with a simple 10-minute weekly check-up. There was no change reported to pain or during the six-week intervention, though this is likely due to the limitation of only using healthy non-symptomatic subjects. Under the same conditions, it is expected that subjects' would report improvements to pain in a symptomatic population.

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The NeckX® equipment was an easy tool to implement the resistance band exercise regimen. Equipped with a fastening skullcap, three various level resistance bands, instruction guidelines, and carrying bag, the NeckX® provided all of the components needed to conduct the regimen. The instruction guidelines also made it easy for subjects to remember the exercises and techniques each day. The carrying bag allowed for easy transport when necessary. The fastening skullcap and resistance bands with safety loops provided an extra level of security during the study; however, it is believed that the same results and data outcomes from this study would be obtained using similar, less expensive, and more readily available equipment (e.g., a swim cap and therapeutic elastic bands).

CROM

The findings in this study show CROM significantly improved in all directions after six weeks, with most directions significantly improving after only three weeks. These findings show that acutely prescribed short daily sessions of cervical spine directed resistance band exercises can effectively improve CROM. Improving and maintaining the functional CROM of our aviators is pertinent to sustaining our Warfighter's safety, health, and combat readiness. Limited CROM can impact the performance of typical tasks and increase compensatory movement through the lower back and hip joints that can lead to further complications (Bennett et al., 2002).

Previous studies on cervical spine-directed exercise fail to consistently incorporate measures of CROM, even though reports show reduced CROM in patients with a history of neck pain (Burnett et al., 2005; Nagai et al., 2014, Äng & Harms-Ringdahl 2006), making it difficult to compare the findings to other interventions. However, one study (Highland et al., 1992) found that the range of motion between flexion and extension improved approximately nine degrees after eight weeks of dynamic neck extensor training. The findings from the present study showed that the range of motion between flexion and extension improved approximately 16 degrees. This comparison aligns with the acceptance that conducting the exercise through the full range of motion, along with a dedicated stretching portion during each repetition, would result in a greater increase in range of motion than an intervention that focuses on neutral position strengthening and stabilization. Further research is needed to determine the functional implications of these changes, to assure the findings can be applied to a symptomatic population, and to compare these findings to a stretching-only regimen.

Strength

The focal strength outcomes (isometric strength, exercise repetitions, and subjective questions) from the measurements taken are that statistically significant improvements for isometric strength were seen in extension; however, the improvements in flexion we not statistically significant. Isometric flexion and extension strength increased by 17.4% and 31.1%, respectively. The observed increases correspond with other reports of increased flexion and extension strength percentages found in other cervical spine-directed interventions (Geary et al., 2014; Conley et al., 1997; Ylinen et al., 2006; Leggett et al., 1991). In comparison, those intervention exercise programs lasted from 5 weeks to 12 months and consisted of 1-3 sessions per week lasting 15-60 minutes.

Isometric cervical spine strength has an essential role in positioning and stabilizing the head, which influences performance and injury risk (Hyrsomallis, 2016), with reports that muscle activation of the cervical spine increase two- to four-fold in military aircrew while using night vision goggles (Harrison et al., 2016). Though only tested in the sagittal plane due to the complexity of assessments, the findings in this study show that the isometric strength of the neutral cervical spine can be increased, even without specifically training in an isolated neutral spine position (as our participants trained over full range of motion). Thus, strength improvements were potentially made throughout all planes and ranges of motion. It is important to consider strength outside of the neutral isometric position, as military aircrew members are frequently scanning their surroundings with reports having shown significantly higher muscle activity during movements in the flexed and the ipsilateral rotated positions (Thuresson et al., 2003). The exercise repetition results reflect strength improvements throughout the full range of motion as subjects were able to complete significantly more repetitions through full range of motion for each exercise, except extension, after the intervention. Further research is needed to quantify the full effects of the intervention on cervical spine musculature isometric strength, length-tension curves, and aircrew member mission performance.

Muscular Control

The improved performance on the muscular control (% time on target) assessment indicates that the exercise regimen resulted in subjects being able to produce and maintain specified forces over short durations of time more accurately. Similar proficiency improvements have been shown to increase pilots' skills in relation to takeoff, general air work, navigation, tactical information, bombing, tactics, and landing (Gawron, 2019).

Though not directly measured, these improvements may be due to neural adaptations, such as improved motor-unit recruitment or decreased antagonist activation, that elicit the ability to more accurately produce a targeted force output; training effects which have been documented within the first two months of an exercise intervention (Häkkinen & Komi, 1983; Moritani & de Vries, 1979). These adaptations occur most rapidly in untrained muscles, and generally, the neck flexors are considered less trained than the neck extensors due to human anatomy that places the neck in a state of extension when erect. The reported muscular control results are in agreement with this ideology; significant improvements in flexion occurred after three and six weeks, while extension only significantly improved after six weeks.

Subjective Questions

Though the study was not designed to accentuate the subjective questions, findings from the subjective questions suggest that subjects had a perceived increase in flexibility at the mid-point and post-intervention, and a perceived increase in strength and stiffness post-intervention. These findings align with the CROM and strength assessment results also presented in this study in which increases in range of motion were seen at the mid- and post-assessment, while increases in strength were only observed post-intervention.

Limitations and Future Investigations

After early recruitment struggles, all subjects were enrolled in the exercise group to preserve effect size. Future investigations into the effects of resistance band exercise on the cervical spine should include a viable control group to make an unequivocal comparison of findings. Despite the study criteria excluding participants who had completed specified neck exercises within the past 12-months, it is not expected that baseline measurements would have changed over the course of six weeks without intervention. Furthermore, all subjects enrolled in this study were healthy males. Future investigations should explore the effects of resistance band exercise in females, as well as symptomatic populations to gain a better understanding of pain outcomes. Endurance assessment results are to be reported in a future publication.

Conclusions

The findings of this study demonstrate that cervical spine directed resistance band exercise regimen is an effective training method for increasing CROM, isometric strength, and muscular control. The exercise regimen was well received and had excellent adherence by the subject population. The resistance bands provided an easy way to self-select and apply resistance, which may allow for more effective use in symptomatic populations as compared to other regimens. The NeckX® is a convenient tool to administer a cervical spine resistance band regimen, though cheaper and more readily accessible options (e.g., a swim cap and therapeutic elastic bands) are likely to give similar results. While the subject population consisted of military aviators exclusively, the exercise regimen has implications for the general public, both therapeutically and prophylactically. Future work will leverage these findings to develop and incorporate operationally-specific training and treatment interventions to optimize Soldier performance.

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Appendix A. Acronyms and Abbreviations

AL	Alabama
CROM	Cervical Spine Range of Motion
DHP	Defense Health Program
DMSS	Defense Medical Surveillance System
EMG	Electromyography
GUI	Graphical User Interface
HSM	Head-Supported Mass
IMVC	Isometric Maximal Voluntary Contractions
IRB	Institutional Review Board
JPC	Joint Program Committee
MA	Massachusetts
MD	Maryland
MN	Minnesota
NATO HFM RTG-252	North Atlantic Treaty Organization Human Factors and Medicine Research Task Group Panel 252
NAWCAD	U.S. Naval Air Warfare Center Aircraft Division
ORISE	Oak Ridge Institute for Science and Education
SD	Standard Deviation
SC	Splenius Capitis
SCM	Sternocleidomastoid
TRAP	Trapezius
USAARL	U.S. Army Aeromedical Research Laboratory

Appendix B. Aircrew Neck Pain Survey

Aircrew Neck Pain Survey

SECTION 1: Personal Details

Please fill in the blanks or check the boxes as appropriate.

Participant Number: _____
Date you've completed this survey: _____

Q1. i. Age: _____

ii. Gender: Male [ ] Female [ ]

iii. Height: _____ft _____in

iv. Weight: _____lbs

v. Please fill in the following table to indicate, on average, how often you have exercised over the last year and what form of exercise you have undertaken.

	Aerobic exercise (e.g., running, cycling)	Weight lifting	Specific neck exercises	Other _____ (please specify)
Everyday	[ ]	[ ]	[ ]	[ ]
2-5 times per week	[ ]	[ ]	[ ]	[ ]
Once per week	[ ]	[ ]	[ ]	[ ]
1-3 times per month	[ ]	[ ]	[ ]	[ ]
Less than once per month	[ ]	[ ]	[ ]	[ ]
Never	[ ]	[ ]	[ ]	[ ]

Q2. i. In which year did you begin your military flying career?

Year: _____

ii. What is your current aircrew position?

Pilot [ ]

Crew Chief [ ]

RIO [ ]

WSO [ ]

Other (please specify) [ ] _____

iii. Are you a designated military flight instructor?

No [ ]

Yes [ ]

If yes, please specify instructor qualifications:

iv. From your log book, please indicate your total number of flight hours to date:

Total flight hours _____

v. Please specify the types of aircraft you have flown or crewed within the last **ten** years. Include the total number of years and the approximate number of hours logged in each (e.g., F/A-18D, 2 years, 300 hours or UH-60A, 5 years, 1000 hours):

Aircraft type	Total years in aircraft	Total hours in aircraft

SECTION 2: Helmets and Night Vision Goggles

Q3. i. Please indicate which type of flight helmet you most commonly use by circling the box with the 'X' that matches the aircraft you've flown:

ROTARY WING AIRCRAFT (NAVY)

Helmet Designation	AH-1	UH-1N	TH-57	UH-1N (SAR)	SH-3D	VH-3A	CH-46D	HH-46A	UH-46A	UH-46D	CH-46E	SH-60	CH-53D pilot & copilot	CH-53D crew	CH-53E	MH-53E	RH-53D	V-22
HGU-67/P	X																	
HGU-84/1P															X	X	X	
HGU-84/2P		X	X															
HGU-84/3P				X														
HGU-84/4P														X				
HGU-84/5P					X	X	X	X	X	X	X							
HGU-84/6P												X						
HGU-84/7P													X					
HGU-84/8P																		X

ROTARY WING AIRCRAFT (ARMY)

Helmet Designation	AH-1 series	UH-1H	OH-58A/C	OH-58D	TH-67	UH-60A/L/M	AH-64A/D	CH-47D/F	LUH-72
SPH-4/B	X	X	X	X	X	X		X	
HGU-56/P			X	X	X	X		X	X
IHADDS							X		

FIXED WING AIRCRAFT

Helmet Designation	F/A-18	F-16	F-14	F-5	AV-8B	S3	E-2C	TE-2C	EA-6B	P-3	C-2	T-2	TA-4F, J	T-6	TA-7C	TAV-8B	T-25	T-34 B/C
HGU-55A/P (USAF helmet)	X																	
HGU-66(V)/1P (has NVG mount)	X																	
HGU-68(V)/P	X	X	X						X			X	X	X	X	X	X	
HGU-68(V)1/P				X							X							X
HGU-68(V)2/P										X								
HGU-68(V)3/P						X												
HGU-68(V)4/P							X	X										
HGU-68(V)6/P																		
HGU-85(V)/1P (has NVG mount)					X													
HGU-87(V)/P22P-16 (Combat Edge)	X																	
HGU-89/P22P-16 (-85 w/Combat Edge)																		

Other (please specify) [ ] _____

Helmet Designation	AH-1	UH-1N	TH-57	UH-1N (SAR)	SH-3D	VH-3A	CH-46D	HH-46A	UH-46A	UH-46D	CH-46E	SH-60	CH-53D pilot & copilot	CH-53D crew	CH-53E	MH-53E	RH-53D	V-22
HGU-67/P	X																	
HGU-84/1P															X	X	X	
HGU-84/2P		X	X															
HGU-84/3P				X														
HGU-84/4P														X				
HGU-84/5P					X	X	X	X	X	X	X							
HGU-84/6P												X						
HGU-84/7P													X					
HGU-84/8P																		X

ROTARY WING AIRCRAFT (ARMY)

Helmet Designation	AH-1 series	UH-1H	OH-58A/C	OH-58D	TH-67	UH-60A/L/M	AH-64A/D	CH-47D/F	LUH-72
SPH-4/B	X	X	X	X	X	X		X	
HGU-56/P			X	X	X	X		X	X
IHADDS							X		

FIXED WING AIRCRAFT

Helmet Designation	F/A-18	F-16	F-14	F-5	AV-8B	S3	E-2C	TE-2C	EA-6B	P-3	C-2	T-2	TA-4F, J	T-6	TA-7C	TAV-8B	T-25	T-34 B/C
HGU-55A/P (USAF helmet)	X																	
HGU-66(V)/1P (has NVG mount)	X																	
HGU-68(V)/P	X	X	X						X			X	X	X	X	X	X	
HGU-68(V)1/P				X							X							X
HGU-68(V)2/P										X								
HGU-68(V)3/P						X												
HGU-68(V)4/P							X	X										
HGU-68(V)6/P																		
HGU-85(V)/1P (has NVG mount)					X													
HGU-87(V)/P22P-16 (Combat Edge)	X																	
HGU-89/P22P-16 (-85 w/Combat Edge)																		

Other (please specify) [ ] _____

Do not know [ ]

ii. Have you ever used night vision goggles (NVGs)?

Yes [ ] No [ ]

IF "NO" GO TO Q4

iii. From your log book, what is your total number of hours flying with NVGs to date and in the last 28 days?

Total NVG hours: _____ Total NVG hours in last 28 days: _____

iv. How long do you typically wear NVGs during a night flight?

Average hours of NVG use per night flight: _____

v. For each NVG type you have used AN/AVS-9(R) for rotary wing (Navy), AN/AVS-6 (Army), and AN/AVS-9(V) for fixed wing please indicate:

a. the aircraft flown while wearing that type of goggle
b. the number of flight hours using that aircraft / goggle combination
c. the date that combination was last flown
d. if a counterbalance weight is **usually** used
e. the weight of the counterbalance usually used (indicate oz or grams)

NVG Type	Aircraft	Flight hours with NVG	Date last flown	Counterbalance	Average weight
_____	_____	_____	_____	Yes [ ] No [ ]	_____
_____	_____	_____	_____	Yes [ ] No [ ]	_____
_____	_____	_____	_____	Yes [ ] No [ ]	_____
_____	_____	_____	_____	Yes [ ] No [ ]	_____
_____	_____	_____	_____	Yes [ ] No [ ]	_____
_____	_____	_____	_____	Yes [ ] No [ ]	_____
_____	_____	_____	_____	Yes [ ] No [ ]	_____

SECTION 3: Neck Strain, Neck Pain, or Neck Injury

The following questions should be answered with regard to your experiences of any neck related symptoms:

Q4. i. Over the past 6 months, have you experienced neck pain /strain that was **unrelated** to flying?

Yes [ ] No [ ]

If "Yes", please describe the cause and the symptoms experienced:

ii. Over the past 6 months, have you experienced neck pain /strain that was **related** to flying?

Yes [ ] No [ ]

If "Yes", please describe the cause and the symptoms experienced. In particular, please note any head positions, such as check 6, that were related to discomfort:

iii. Have you noticed any particular flight maneuvers that tended to consistently produce or aggravate neck pain /strain?

Yes [ ] No [ ]

If "Yes", please describe the cause and the symptoms experienced:

IF "NO" GO TO Q5

iv. Please indicate if you think your neck pain was associated with any of the following circumstances:

(A brief explanation of the circumstances would be helpful)

Student pilot status [ ]

Instructor pilot status [ ]

Infrequent flying duties [ ]

Recent illness/injury [ ]

Particular mission type [ ] _____

Particular type of helmet [ ] _____

Q5. i. Over the past 6 months, have you experienced neck pain **during** flight?

Yes [ ] No [ ]

IF "NO" GO TO Q6

ii. Please indicate the total number of episodes of neck pain you have experienced **during** flight during the past 6 months:

1-3 episodes [ ]

4-10 episodes [ ]

More than 10 episodes [ ]

iii. We'd like to assess the relationship between experiencing pain and the type of flight maneuvers performed and your head gear. Please place a check in the table that for a given maneuver and system that was associated with pain **during** flight.

ROTARY WING AIRCRAFT

	Head mounted system		
Maneuver	Helmet only	NVG	Display other than NVG
Basic Flight Maneuvers (BFM)			
Combat Maneuvering Flight			
Hover			
Attack			
Other _____			
Other _____			

FIXED WING AIRCRAFT

	Head mounted system		
Maneuver	Helmet only	NVG	Display other than NVG
low G (<2G)			
moderate G (2-4G)			
high G (4-6G)			
very high G (> 6G)			
Push-pull			

a) Please specify the type of head mounted display you wore that was associated with pain (e.g. NVG, JHMCS)

_____

iv. Over the past 6 months, have you experienced neck pain that was related to equipment other than head mounted systems (e.g. LPU, harness, restraints, seating)?

Yes [ ] No [ ]

If yes, please specify the type(s) of equipment and describe the pain:

Q6. i. Over the past 6 months, have you experienced neck pain **after** flight?

Yes [ ] No [ ]

IF "NO" GO TO Q7

ii. Please indicate the total number of episodes during the last 6 months of neck pain you have experienced **after** flight:

1-3 episodes [ ]

4-10 episodes [ ]

More than 10 episodes [ ]

iii. We'd like to assess the relationship between experiencing pain and the type of flight maneuvers performed and your head gear. Please place a check in the table that for a given maneuver and system that was associated with pain **after** flight.

ROTARY WING AIRCRAFT

	Head mounted system		
Maneuver	Helmet only	NVG	Display other than NVG
Basic Flight Maneuvers (BFM)			
Combat Maneuvering Flight			
Hover			
Attack			
Other _____			
Other _____			

FIXED WING AIRCRAFT

	Head mounted system		
Maneuver	Helmet only	NVG	Display other than NVG
low G (<2G)			
moderate G (2-4G)			
high G (4-6G)			
very high G (> 6G)			
Push-pull			

a) Please specify the type of head mounted display you wore that was associated with pain (e.g. NVG, JHMCS)

_____

iv. Over the past 6 months, have you ever experienced neck pain **after** flight that was related to equipment other than head mounted systems (e.g. LPU, harness, restraints, seating)?

Yes [ ] No [ ]

If yes, please specify the type(s) of equipment and describe the pain:

Using the following scale, please answer the questions below:

***Mild** (noticeable but did not interfere with normal duties)*
***Moderate** (difficult to concentrate on normal duties)*
***Severe** (disrupted ability to perform normal duties)*
***Incapacitating** (unable to perform normal duties)*

Q7. Please indicate the severity of neck pain, for the **worst** episode of pain experienced during the last 6 months:

		Mild	*Moderate*	*Severe*	*Incapacitating*	*Not Applicable*
i.	**during** flight:	[ ]	[ ]	[ ]	[ ]	[ ]
ii.	**after** flight:	[ ]	[ ]	[ ]	[ ]	[ ]

Q8. If you commonly experience neck pain, please indicate an **average** severity of pain experienced during the last 6 months:

		Mild	*Moderate*	*Severe*	*Incapacitating*	*Not Applicable*
i.	**during flight:**	**[ ]**	**[ ]**	**[ ]**	**[ ]**	**[ ]**
ii.	**after** flight:	[ ]	[ ]	[ ]	[ ]	[ ]

Q9. i. How long did the symptoms persist for the **worst** episode of neck pain during the last 6 months?

During flight only	[ ]	12-24 hours after flight	[ ]
Less than 2 hrs after flight	[ ]	1-4 days after flight	[ ]
2-11 hours after flight	[ ]	More than 4 days after flight	[ ]

ii. How long do the symptoms usually persist for the **average** episode of neck pain during the last 6 months?

During flight only	[ ]	12-24 hours after flight	[ ]
Less than 2 hrs after flight	[ ]	1-4 days after flight	[ ]
2-11 hours after flight	[ ]	More than 4 days after flight	[ ]

Q10. i. During the last 6 months, have you sought treatment for any occurrence of flight related neck pain?

Yes [ ] No [ ]

IF "NO" GO TO Q11

ii. Was the treatment sought from:

Medical officer	[ ]	Physical therapist	[ ]
Osteopath	[ ]	Civilian doctor	[ ]
Chiropractor	[ ]	Self medicate	[ ]
Pharmacist	[ ]	Other (please specify)	[ ]

_____

iii. Were you given any treatment for your neck pain?

Yes [ ] No [ ]

If "Yes", please describe briefly the treatment you received:

Q11. i. Have you ever been grounded as a result of flight-related neck pain?

Yes [ ] No [ ]

IF "NO" GO TO SECTION 4

If "Yes", please indicate for how long you were grounded:

>1	month	[ ]	<1 week	[ ]
3-4	weeks	[ ]	currently grounded	[ ]
1-2	weeks	[ ]		

If you are currently grounded, please state the length of time you have been grounded for so far:

Length of current grounding period: _____

ii. Have you ever taken any action in order to minimize or avoid flight-related neck pain?

Yes [ ] No [ ]

If "Yes", please describe the type of action taken and if the action taken was effective:

SECTION 4: Additional comments

Please use this area to provide any additional information about your experiences:

This space is intentionally blank.

Appendix C. NeckX Brochure

INCREASE STRENGTH, FLEXIBILITY, RANGE OF MOTION AND ENDURANCE

NECKXSYSTEMS™ GUIDELINES & EXERCISE INSTRUCTIONS

www.NeckXsystems.com | NeckX® is Patented

For exercise videos, visit www.NeckXSystems.com

GUIDELINES

NeckX® is an innovative neck exercise device designed by NeckXsystems™ to help stretch and strengthen neck musculature. Using NeckX® can increase endurance and flexibility and ultimately improve range of motion. NeckX® is a lightweight, portable device that allows the user to quickly change from targeting one muscle group to the next. NeckXsystems™ provides the user the ability to continue the exercise regimen prescribed by their medical professional or recommended by their personal trainer in the comfort of their own surroundings, resulting in faster and longer term results. Give NeckX® a try and see what it can do for you.

Before using the NeckX® or starting and participating in any new exercise routine, always consult with your physician or health care professional and discuss if NeckX® is safe for you to use. In addition, you should also use the NeckX® under the supervision of a physician, health care professional, certified trainer or coach, physical therapist, chiropractor, or orthopedic / neck specialist. Finally, if you feel any pain or experience any abnormal symptoms, stop using NeckX® immediately and consult with your physician or health care professional before continuing use.

Please follow these safety guidelines when using this product. If used improperly, the NeckX® can cause injury.

- Read all instructions carefully before using.
- Always consult your physician or health care professional before starting or participating in any new exercise routine.
- Always use NeckX® under the supervision of a physician, health care professional, certified trainer or coach, physical therapist, chiropractor, or orthopedic / neck specialist.
- Always use the safety wrist loops at the end of the bands as prescribed in this document to help prevent injury.
- Inspect the product for damage or flaws before each use.
- Do not use if the loops on the side of the cap, which help position the exercise band on the head, are loose, torn, frayed, or separating from the cap.
- Do not use the exercise bands or any exercise band that has holes (except for the safety wrist loops) or small nicks which may cause the band to tear or break during exercise.

- Do not grasp, attach to any object, or use the safety wrist loops as a means of leverage when using NeckX®. The safety wrist loops should never be used as handles.
- Never shorten the length of the exercise bands. The exercise bands used with NeckX® should never be shorter than six feet (72 inches) in length.
- Never use tape of any kind to attach the exercise bands to stationary objects.
- Keep the exercise bands away from heat, cold, and sharp objects to avoid accidental punctures and tears. Avoid exposing the exercise bands to direct sunlight or water and store in a cool (21°C/70°F), dark area.
- Never stretch the exercise bands to more than three times their resting length.
- Never stretch and release the exercise bands. Always maintain a firm grip and never release the exercise band until you have manually returned it to its resting length.
- Never tie two pieces of exercise bands together.
- Always use NeckX® in an open area that is free from obstructions.
- This product should not be considered to be or used as a toy.
- The life expectancy of the exercise bands are consistent with that amount of usage sustained. As a precaution, the exercise bands should be replaced at a minimum every year. Heavy use may require accelerated replacement.
- If the exercise bands, cap, or safety wrist loops are damaged in anyway, do not use and replace before continuing to use NeckX®.
- This product is intended for use only as described in this document or as prescribed by a physician, health care professional, certified trainer or coach, physical therapist, chiropractor, or orthopedic / neck specialist.
- NeckX® LLC assumes no liability for injuries, accidents, or damages that may occur with the use or misuse of this product.

The portable NeckX® allows you to do your exercises anywhere and can be done while standing, sitting or lying down. It is important to breathe while doing the exercises and relax as you take your neck through your normal range of motion. Neck exercises are to be done pain free, smooth and with slow controlled motions at all times. Neck stretches are done to a count of 20 seconds and repeated one to three repetitions. Neck exercises are done for 8 to 10 repetitions (unless otherwise instructed by a health care professional). Begin by holding for 2 seconds at the end of the range of motion. Return slowly counting for 4 seconds to the start of the position. All neck exercises can be done with breaks when muscles are feeling fatigued. Neck stretching and strengthening should not produce or increase any pain. For best results, neck exercises should be performed once a day. If at any time you feel any pain or experience any abnormal symptoms, stop using NeckX® immediately and consult with your physician or health care professional before continuing use.

INSTRUCTIONS

Upon opening your package, inventory your NeckX® device and ensure that you have all the components listed here:

- NeckX® Adjustable Cap
- 3 NeckXsystems™ Exercise Bands (Yellow, Green, Blue)
- NeckXsystems™ Guidelines and Exercise Instructions
- NeckX® Carrying Pouch

NeckXsystems™ bands are color coded with respect to the resistance they provide:

Yellow = Light
Green = Medium
Blue = Heavy

Also, you should immediately inspect the cap, exercise bands, and safety wrist loops at the ends of each band, for any damage or flaws before each use. If any damage or flaws are noticed in accordance with, but not limited to, the advice contained in the Guidelines section, do not use the NeckX® device. Contact the NeckXsystems™ customer service department.

After inspecting the components of your NeckX® device and after consulting with your physician or health care professional, you are ready to begin using the NeckX®. To correctly assemble the NeckX® and to ensure its safe use, you should follow the assembly instructions on the next page.

ASSEMBLY/USAGE INSTRUCTIONS

Choose which exercise band you wish to start with. It is highly recommended that you begin with the band that offers the least resistance until you have perfected the exercises and to prevent possible injury.

Step 1: Feed the exercise band through the side loops on each side of the cap above the chin straps. Adjust the exercise band so that the band is even on both sides and the NeckX® logo is centered on top.

Step 2: Place the NeckX® on your head so that the bottom of the cap runs across the forehead, slightly above the eyebrows. Look in a mirror to ensure the NeckX® logo is centered above your nose and attach the chin strap.

Step 3: If the cap is loose, use the Velcro adjustment tab on the back to assist in a more secure fit.

Step 4: Slip your hands through the safety wrist loops and then grasp the exercise bands. Do not grasp the safety wrist loop to perform the exercises.

Caution: The exercises and instructions detailed in this guide are for reference only and are not intended to act as a prescription for exercise. Before using the NeckX®, starting or participating in any new exercise routine, always consult with your physician or health care professional and discuss if NeckX® is safe for you to use. In addition, you should also use the NeckX® under the supervision of a physician, health care professional, certified trainer or coach, physical therapist, chiropractor, or orthopedic/neck specialist. Finally, if you feel any pain or experience any abnormal symptoms, stop using NeckX® immediately and consult with your physician or health care professional before continuing use.

EXERCISE TIPS

- The goal of using the NeckX® is to gradually increase the amount of repetitions to build endurance.
- Neck stretches are done to a count of 20 seconds and repeated one to three repetitions.
- Neck exercises are done for 8 to 10 repetitions *(unless otherwise instructed by a health care professional).*
- Begin by holding for 2 seconds at the end of the range of motion.
- Return slowly counting for 4 seconds to the start of the position.
- If greater resistance is desired, you may consider using two bands simultaneously.
- The NeckX® may also be used while lying down. For suggested positions, review the pictures at the end of the exercise section.

NEUTRAL SPINE POSITION (NSP)

NSP Technique:

- Sit up straight, shoulders back.
- Look straight ahead.
- Put hands through safety wrist loops.
- Hands are holding resistance bands and resting at hips.
- Start and end all exercises in the Neutral Spine Position.

Note: It is recommended that the following steps and all recommended exercises be done in front of a mirror to help ensure the proper placement of the NeckX® upon your head. Furthermore, using a mirror will help you maintain a Neutral Spine Position for all recommended exercises and allow you to evaluate technique and ensure proper movement.

1. SIDE BEND
(LEFT OR RIGHT)

Step 1: Position band on top of head. Hold left arm out, slightly above waist at a 45° angle. This exercise can be done to the left and right.

Step 2: Tilt head to the left, feeling the stretch along the right side.

Step 3: For resistance, tilt head to the right, keeping your left hand in place, return your head back to the left and repeat.

2. RETRACTION/ CHIN TUCK

Step 1: Position band on back of head. Lift arms to the front, above shoulder level, holding the bands at the desired level of resistance.

Step 2: Tuck chin in and hold, keeping arms in place. Move chin in and out on a horizontal or level plane.

Step 3: Slowly return and repeat.

3. EXTENSION

Step 1: Position band on top of head. Hands are holding resistance band and resting on knees. Lower your chin and stretch the back of your neck.

Step 2: Lift head up and back, increasing the resistance against the band, or, with continuous resistance by lifting arms up as your head extends back.

Step 3: Slowly return and repeat.

4. FLEXION

Step 1: Position band on front of head. Turn your grip upside down with thumbs facing downward.

Step 2: Wrap bands around the back of your shoulders and behind your elbows. Lift top of head up, increasing resistance against band.

Step 3: Tuck chin in and bring towards chest, without bending body forward. Slowly return and repeat.

5. ROTATION
(LEFT SIDE)

Step 1: Position band on top of head. With your left hand, wrap the band around the front of the NeckX® cap, continuing around back and hold out at a 90° angle.

Step 2: Turn your head to the right, feeling the stretch along the left side. Ensure that you are holding the bands. Do not hold the safety wrist loops.

Step 3: For resistance, turn your head to the left, slowly return back to the right.

(RIGHT SIDE)

Step 1: With your right hand, wrap the band around the front of the NeckX® cap, continuing around the back and hold out at a 90° angle.

Step 2: Turn your head to the left, feeling the stretch along the right side. Ensure that you are holding the bands. Do not hold the safety wrist loops.

Step 3: For resistance, turn your head to the right, slowly return back to the left.

6. 45°s

Step 1: Position band on top of head. Begin in Neutral Spine Position, hands are resting at hips.

Step 2: Lift head up and rotate to the right while looking up and over your shoulder, and hold.

Step 3: Slowly return your head back through the Neutral Spine Position and look down at your left hand. Repeat to the right as necessary.

7. VERTICAL LIFT

Step 1: Position band on top of head. Securely hold the resistance bands at each end with wrists through the safety wrist loops and resting at hips.

Step 2: Lift top of head up towards ceiling, without lifting your chin. You may engage core muscles as well.

Step 3: Slowly return to Neutral Spine and repeat.

EXERCISES LYING DOWN

CHIN TUCK: Position band at back of head. Hold arms straight up using desired amount of resistance. Raise chin vertically and back down.

SIDE BEND Step 1: Hold arm out to left or right side at a plus 45° angle.

SIDE BEND Step 2: Imagine head resting on a dime. Tilt head to left and right while resisting the temptation to turn your chin.

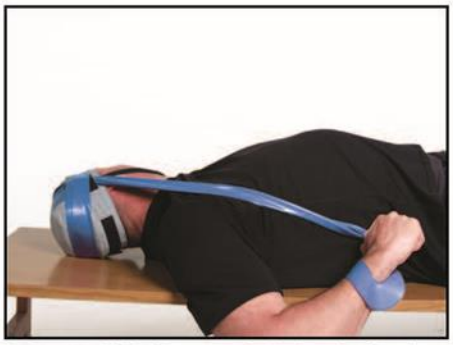
EXTENSION Step 1: Position band at back of head. Raise arms to a 45° angle using desired amount of resistance.

FLEXION Step 2: Move chin towards chest. After desired range of travel, slowly allow head to move back towards the table.

EXTENSION Step 2: Slowly allow head to come forward. After desired range of travel, move head back towards table.

ROTATION Step 1: Wrap band around front of head as previously described in Rotation Exercise and hold arm out at 90° angle (left arm at 90° angle not shown).

FLEXION Step 1: Position band on front of head. Wrap bands behind shoulders and elbow. Hold arms at side.



ROTATION Step 2: Pull the desired amount of resistance to stretch. If desired, head may be turned to the left and right to work range of motion.

Notes

INCREASE STRENGTH, FLEXIBILITY, RANGE OF MOTION AND ENDURANCE

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NeckX® is Patented - #8,613,690

Appendix D. Subject Weekly Log

NAWCAD NECK PAIN STUDY WEEKLY LOG UPDATE
CONFIDENTIAL WHEN COMPLETED

Participant number: _____ Total number flight hours this week: _____

Date completed: _____ Hours flown with NVG/HMD this week: _____

1. Did you experience neck ache / pain /strain **related** to flying this week? Yes [ ] No [ ]

If yes, list the number of neck pain episodes you experienced: [ ]

If yes, on average, check the box indicating how long the pain persisted:

0-1 hr	1-2 hr	2-4 hr	4-8 hr	8-12 hr	12-24 hr	24-36 hr	36-48 hr	More than 48 hr
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Rate the average flying-related pain severity by checking the box along this line:

0 (No pain)	1	2	3	4	5	6	7	8	9	10 (Maximum pain)
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Rate the worst flying-related pain severity by checking the box along this line:

0 (No pain)	1	2	3	4	5	6	7	8	9	10 (Maximum pain)
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

2. Did you experience neck ache / pain /strain **unrelated** to flying this week? Yes [ ] No [ ]

If yes, describe the cause and the symptoms experienced:

If yes, list the number of neck pain episodes you experienced: [ ]

If yes, on average, check the box indicating how long did the pain persisted:

0-1 hr	1-2 hr	2-4 hr	4-8 hr	8-12 hr	12-24 hr	24-36 hr	36-48 hr	More than 48 hr
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Rate the average non-flying-related pain severity by checking the box along this line:

0 (No pain)	1	2	3	4	5	6	7	8	9	10 (Maximum pain)
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Rate the worst non-flying-related pain severity by checking the box along this line:

0 (No pain)	1	2	3	4	5	6	7	8	9	10 (Maximum pain)

[ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

3. Did you exercise this week? Yes [ ] No [ ]

If yes, check the box indicating how many hours you did the **prescribed exercises**:

1-2	**3-5**	**6-7**	**8-10**	**11-13**	**14**	**Not applicable**
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Check the box indicating how many hours you did **aerobic exercise**:

1-2	**3-5**	**6-7**	**8-10**	**11-13**	**14**	**Not applicable**
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Check the box indicating how many hours you did **weight lifting**:

1-2	**3-5**	**6-7**	**8-10**	**11-13**	**14**	**Not applicable**
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

4. Did you have spinal manipulation (Musculoskeletal Manipulation Treatment)? Yes [ ] No [ ]

If yes, check the box indicating how many times:

1	**2**	**more than 2**
[ ]	[ ]	[ ]

Was the manipulation carried out as part of the Neck Pain Study? Yes [ ] No [ ]

5. Were you evaluated by a clinician for neck pain? Yes [ ] No [ ]

6. Were you evaluated by a clinician for any condition other than neck pain? Yes [ ] No [ ]

If yes, briefly describe the condition:

7. Did you take any prescribed medication for neck pain? Yes [ ] No [ ]

If yes, list the name, dosage, and amount taken this week:

8. Did you take any over the counter medication for neck pain? Yes [ ] No [ ]

If yes, list the name, dosage, and amount taken this week:

9. Are you currently on a "profile" or "light / limited duty"? Yes [ ] No [ ]

If yes, give the details and reasons for the restriction:

Was the restriction temporary? Yes [ ] No [ ]

Appendix E. Medical History Screen

*DATE*_____

MEDICAL HISTORY SCREEN (HEAD/NECK)

SUBJECT NAME_____ AGE (18-45) _____ WEIGHT_____(lbs)
TELEPHONE # _____
WORK CENTER _____

Please answer the following medical questions honestly and to the best of your ability. If you do not understand a question, please ask. The accuracy of this screening form will help to ensure your safety and medical suitability for study participation.

1. Have you ever had a significant Cervical/Spinal Injury or condition such as: (**check below**)
   _____ fracture/dislocation
   _____ bulging, herniated, ruptured or compressed disk(s)
   _____ whiplash
   _____ chronic/recurring neck or back pain
   _____ painful or swollen joints, arthritis, or other muscle/skeletal disorder

2. Are you now, or have you ever been, under the care of a physician or chiropractor for back/neck injury or disorder? Yes No

   If yes, explain when, why, and current condition:_____
   _____
   _____

3. Do you currently have any **other** chronic or recurrent medical problems? Yes No
   If yes, describe: _____
   _____
   _____

4. Do you have any significant physical limitations? Yes No
   Are you on a duty limiting profile (permanent or temporary)? Yes No
   If yes, describe: _____
   _____
   _____

5. **Female subjects:** Are you, or could you possibly be, pregnant at this time? Yes No

6. Are you currently taking any medications (including inhalers, patches, over-the-counter medications, herbals, and nutritional supplements, or birth control pills)? Are you engaged in therapeutic massage? Yes No
   If so, what?_____
   _____
   _____

7. Do you have any artificial body parts, missing limbs or fingers? Yes No

8. Have you ever had any major surgery? Yes No
   If yes, explain when, why: _____
   _____

9. Will you be available for this project and follow-ups? Yes No
_____ dynamic assessment
_____ work/rest cycle
_____ reliability

Additional comments:

Signature_____ Date_____

STUDY PHYSICIAN NOTES/COMMENTS ONLY BELOW:

Does the volunteer possess a current, validated medical flying certificate ("up slip" or up chit") Yes No
Significant Past Medical History:_____
Significant Past Surgical History:_____
Medications:_____
Does the volunteer currently have neck pain? Yes No
If YES, are there symptoms of serious etiology? Yes No
(History of recent significant fall or major trauma? Unexplained weight loss? Fever, chills, or constitutional symptoms? History of cancer, immunosupression, or chronic steroid use? History of intravenous or injection drug use? Neurologic signs or symptoms (bowel/bladder dysfunction, radicular symptoms, gait difficulty or extremity weakness, numbness/tingling/dysesthesias)? History of rheumatologic disease, associated headache, or visual symptoms? Anterior neck pain?)
Notes:_____

* The above medical history has been reviewed and the subject is found to be:
(**circle one**) Physically Qualified / Not Physically Qualified to participate in this study.

Reviewed by_____ Date_____
Medical Representative

U.S. Army Aeromedical Research Laboratory
Fort Rucker, Alabama

All of USAARL's science and technical information documents are available for download from the Defense Technical Information Center.

https://discover.dtic.mil/results/?q=USAARL

Army Futures Command
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