EXERCISE REGIMEN FOR MITIGATION OF ACUTE AND CHRONIC NECK PAIN IN MILITARY AIRCREW

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A Major Pain in the Neck...

- Neck pain has a **lifetime** prevalence of 48.5%\(^1,2\)
- Military pilots are especially susceptible\(^3\):
  - G-loading and helmet loads
  - Vibratory loads and cockpit ergonomics
  - Ejection-associated rapid loading
  - Impact with terrain causing spinal fractures
  - Neck muscle fatigue from missions
- This leads to a **yearly** prevalence of 56%\(^4\)
The Many Shapes and Forms of C-Spine Insult

Fig. 1 – G-loading during a “Check 6”

Fig. 2 – Helmets providing asymmetric loading

Fig. 3 – Traumatic landings

Fig. 4 – Lack of ergonomic seating
Even Space Will Not Spare Your Neck…

- Astronauts, some of whom are former military pilots, are at risk for:
  - herniated nucleus pulposis upon return to Earth noted
  - neck pain during EVA training

Fig. 5 – Herniation of nucleus pulposis posterolaterally
Affected Musculature

- Military pilots with chronic neck pain present with:
  - reduced neck range of motion\(^8\)
  - weakness and fatigue of deep, segmental neck muscles\(^9\)

Fig. 6 – Deep segmental neck muscles
Exercise as a Countermeasure

- Prior studies show that stretching and strengthening exercises reduce neck pain and improve muscle function\textsuperscript{10,11}
- Portable exercise devices are a particularly attractive option
**DESCRIPTION:** NeckX™ is a lightweight, portable neck exercise device that stretches & strengthens neck musculature to increase flexibility & stamina, reduce the likelihood of injury, relieve pain, and improve mission effectiveness.

**VALUE TO NAVAL WARFIGHTER:**
- Build neck musculature to prepare for the stresses of combat.
- An exercise device and system for targeting physiological components such as muscle groups, connective tissue and structural alignment of the neck and upper body.
- Therapy device for the rehabilitation of non-radicular cervical pain known as somatic dysfunction or mechanical neck pain.
- Improve mission effectiveness by allowing for full ROM of the neck.

**OBJECTIVES**
- Employ in military pilot community, esp. fighter aircraft, to combat the short & long term effects of high +Gz on C-spine.
- Use as a pre-flight warm-up routine to prepare for the rigor of flying in high +Gz sorties.
- Improve posture and cervical strength to deal with the increased weight of helmets & helmet mounted devices (i.e.-JHMCS, NVGs, HMDs etc.)
- Use to maintain full ROM and flexibility for visual capability, target acquisition, & comfort.
- Decrease the occurrences of acute and chronic neck pain suffered by almost 90% of fighter pilots over a career.
- Reduce the number & severity of VA claims related to cervical spine issues and thereby save USN medicine funds & improve long term QOL for retired pilots.

**VARIANTS**
- The NeckX™ system consists of a polyester cap.
- Three levels of Exercise Bands are provided to facilitate increased resistance training. These bands are easily switched and can be fixated to target specific muscle groups.
- Recommended exercises are provided to target the cervical musculature most commonly related to neck muscle strain.

**RECOMMENDATIONS**
- Develop a research protocol to evaluate the effectiveness & safety of the device for the operational flying community.
- Deploy into a select group of new and experienced HPJA pilot squadrons, implement exercise protocols, and assess results.

**NECC** for retired pilots.

*Adaptive, Responsive, Expeditionary*

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Fig. 7 – Description of the NeckX™, a portable neck exercise device
Validation of the Device

Fig. 8 – Study process map used to validate the NeckX with MIT colleagues Dr. Dan Buckland et al.
Our Study’s Personnel

- Collaborative, fleet-wide, and internationally-represented study
- Study funded by the U.S. Department of Defense
- Led by PI Dr. Barry Shender, Ph.D and Assoc. Investigator CAPT Jeff Jones, M.D.
- Co-investigators and collaborators, including study sites:

<table>
<thead>
<tr>
<th>Co-investigator</th>
<th>Location/Base</th>
</tr>
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<tbody>
<tr>
<td>MAJ Monica Sickler</td>
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<td>LT Katherine Lee</td>
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<td>MAG-39, Camp Pendleton, CA</td>
</tr>
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<td>LCDR Christopher Perry</td>
<td>Naval Branch Health Clinic, Mayport, FL</td>
</tr>
<tr>
<td>LT Amy Ostrofe</td>
<td>Naval Medical Center Portsmouth, VA</td>
</tr>
</tbody>
</table>

Fig. 9 – List of current and former study co-investigators and collaborators
Study Objectives

Hypothesis:
Using exercise as a countermeasure for neck pain in pilots by means of a lightweight, portable device can improve ROM, strength, and endurance while also reducing the symptoms and frequency of injury reports in an aviation community.

Objectives:

1. increase ROM, strength, and endurance of the cervical musculature in USN, USA, and USAF aviators
2. reduce neck pain frequency and magnitude
3. quantitatively and qualitatively describe the exposures leading to neck pain in military pilots of our study
Methodology

- Preliminary studies of 3-week exercise regimen showed promising results
- 6 subjects (5M, 1F) enrolled and completed intake survey
- Subjects completed an approximately 12-week exercise program using the NeckX™ 3X/week
- Mean baseline and post-program measurements:
  - cervical strength (resistance)
  - endurance (repetitions)
  - ROM (goniometer)
- Weekly logs
  - pain frequency
  - magnitude (0-10 scale)
  - contributing factors
Intake Questionnaire, Regimen, and Weekly Questionnaire

Fig. 10 – Intake questionnaire captures comprehensive pilot flight history and exposures.

Fig. 11 – Example regimen provided to co-investigators to standardized the intervention.

Fig. 12 – Weekly questionnaire captures weekly changes in symptoms alongside flight times and exposures.

A5. Neck-X protocol synopsis

1. Warm Ups
   a. Neck Retraction: 10 reps x 1 set
   b. Neck Extension: 10 reps x 1 set
   c. Side Bending: Left – 5 reps x 1 set  Right – 5 reps x 1 set
   d. Neck Rotation: Left – 5 reps x 1 set  Right – 5 reps x 1 set
   e. Neck Flexion: 10 reps x 1 set

All warm up exercises, except for Side Bending and Neck Rotation, should be performed with 3 second hold in each direction of motion with a slight pause at neutral for a total of slightly more than 6 seconds per repetition. Side bending and Neck Rotation exercises should come to neutral end position after movement to the left/right sides.

2. EMG: Optional. Perform if the facility has the EMG electrodes.

3. Anthropometrics: Subjects will have their height, weight, head circumference, head width, neck circumference at mid-cervical spine, base neck circumference including trapezius musculature, sitting height, and overall neck length (measured from occiput to T1) measured. Cervical range of motion will be assessed using a commercially available goniometry instrument. Cool-down procedures: After completing a set of exercises, the stretching exercises outlined in paragraph IV.C.1.a will be repeated to cool the muscles down.

4. Neck X Stretches
   a. Neck Retraction/Chin Tucks: 10 reps x 2 sets
   b. Neck Extension: 10 reps x 2 sets
   c. Side Bending: Left – 10 reps x 2 sets  Right – 10 reps x 2 sets
   d. Neck Rotation: Left – 10 reps x 2 sets  Right – 10 reps x 2 sets
   e. Neck Flexion: 10 reps x 2 sets

A2. Participant study log

Navy Cad Neck Pain Study Weekly Log Update Confidential when completed

Participant number: ________  Total number flight hours this week: ________
Date completed: ________  Hours flown with NVG/TMD this week: ________
1. Did you experience neck ache / pain unrelated 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:

<table>
<thead>
<tr>
<th>0-1 hr</th>
<th>1-2 hr</th>
<th>2-4 hr</th>
<th>4-8 hr</th>
<th>8-12 hr</th>
<th>12-24 hr</th>
<th>24-36 hr</th>
<th>36-48 hr</th>
<th>More than 48 hr</th>
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<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
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<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
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</table>

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)

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

If yes, describe the cause and the symptoms experienced:
Pilot Study Results with Cervical Countermeasure Device

Subjects: N= 10 F/A-18 Pilots

Protocol: 3 weeks x 2, bid use- progressively increasing resistance and number repetitions Measurements Pre and Post exercise regimen

Results:

<table>
<thead>
<tr>
<th></th>
<th>Flexion</th>
<th>Extension</th>
<th>Lat Bend</th>
<th>Rotation</th>
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<tbody>
<tr>
<td>Strength Measures</td>
<td>+ 8%</td>
<td>+11%</td>
<td>+13%</td>
<td>+10%</td>
</tr>
<tr>
<td>Endurance Measures</td>
<td>+ 9%</td>
<td>+12%</td>
<td>+10%</td>
<td>+17%</td>
</tr>
<tr>
<td>Flexibility Measures</td>
<td>+ 5%</td>
<td>0%</td>
<td>+ 7%</td>
<td>+ 8%</td>
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</table>

Fig. 13 – Pilot study results of 10 F/A-18 aviators
Preliminary Results of Current Study

- Cohort characteristics:
  - 5 male, 1 female (mean age of 36.3)
  - Exercise frequency:
    - Aerobic: 2-5X/wk (n=6), Weights: 2-5X/wk (n=3), 1X/wk (n=2), <1X/mo (n=1), Neck exercises: <1X/mo (n=3) or never (n=3)
  - Total flight hours: range of **536.5h to 2555.55h** (mean of 1714.18h)
  - Helmets worn: HGU-67/P, HGU-84/2P, HGU-84/6P, HGU-84/8P, OTO (all used NVG with range of 80.2h to 659h of use with mean of 322.3h)
  - All 6 experienced neck pain unrelated to flying; 5/5 actively flying subjects experienced neck pain related to flying
## Preliminary Results

<table>
<thead>
<tr>
<th>Change In Strength</th>
<th>Change In Endurance</th>
<th>Change in Flexibility</th>
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<tbody>
<tr>
<td>Increased flexion (+104%)</td>
<td>Increased flexion (+142%)</td>
<td>Increased flexion (+17%)</td>
</tr>
<tr>
<td>Increased extension (+57%)</td>
<td>Increased extension (+157%)</td>
<td>Increased extension (+36%)</td>
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<tr>
<td>Increased lateral bend (+50%)</td>
<td>Increased lateral bend (+170)</td>
<td>Increased lateral bend (+23%)</td>
</tr>
<tr>
<td>Increased rotation (+47%)</td>
<td>Increased rotation (+217%)</td>
<td>Increased rotation (+63%)</td>
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Subjects reported reduced severity and frequency of neck pain with follow-up range of 10 to 18 weeks.
## Preliminary Results – Case Presentation

<table>
<thead>
<tr>
<th>Week #</th>
<th># Episodes</th>
<th>Persistence</th>
<th>Avg/Worst Severity</th>
<th>Hrs Doing Prescribed Exercises</th>
<th>Hrs of Aerobic Exercise</th>
<th>Hrs Doing Weight Lifting</th>
<th>Spinal manipulation this week?</th>
<th>Q8 Medications?</th>
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<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>&gt;48h</td>
<td>4, 7</td>
<td>1-2h</td>
<td>3-5h</td>
<td>n/a</td>
<td>N</td>
<td>Tylenol 500 mg, 2x</td>
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<tr>
<td>2</td>
<td>5</td>
<td>8-12h</td>
<td>4, 6</td>
<td>1-2h</td>
<td>n/a</td>
<td>n/a</td>
<td>N</td>
<td>Tylenol 500 mg</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>8-12h</td>
<td>5, 8</td>
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<td>N</td>
<td>Tylenol 500 mg</td>
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<td>2</td>
<td>1-2h</td>
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<td>1-2h</td>
<td>3-5h</td>
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<td>N</td>
<td>N</td>
</tr>
<tr>
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<td>4</td>
<td>2-4h</td>
<td>1, 1</td>
<td>1-2h</td>
<td>3-5h</td>
<td>n/a</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
<td>3-5h</td>
<td>3-5h</td>
<td>n/a</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Fig. 15 – Weekly questionnaire log data from one subject
Discussion and Future Directions

- Obtain n of 150 to 200 to maximize statistical significance and power
  - Gather data from a wide array of military pilots and fixed/rotary wing aircraft
  - 1-year post-intervention follow-up to assess symptoms and continued exercise
  - Identify causes of symptomology from intake questionnaires
  - Randomization

- Continue to recruit co-investigators from various fleets, internationally, and from astronaut community
  - Engaging USA, USAF, and international military aviation community investigators for recruiting subjects
  - Working with NASA and other space agencies and muscular conditioning personnel to determine feasibility of NeckX as countermeasure during spaceflight
  - Parallel study in non-aviation sports and cervical spine patients
Long-term Vision

- Include a portable, lightweight exercise device as part of introductory military pilot and astronaut materials
  - long-term, self-directed cervical spine health
References


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