

# CERVICAL EXERCISE REGIMEN FOR PREVENTION AND MITIGATION OF ACUTE AND CHRONIC NECK PAIN IN HIGH-PERFORMANCE AIRCREW

Ryan J. Keller<sup>1</sup>, Reece Rosenthal<sup>1</sup>, Sawan Dalal<sup>1</sup>, Jeffrey A. Jones<sup>1,2</sup>, Bethany Shivers<sup>3,4</sup>, Barry Shender<sup>3</sup>, Brian Novotny<sup>4</sup>, Sheryl Vandeven<sup>2</sup>, Nicole Butler<sup>1</sup>, Daniel O'Connor<sup>1</sup>, Daphne Ryan<sup>5</sup> Vignesh Ramachandran<sup>1</sup>

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## Background

- Operators of Rotary-Wing Aircraft (RWA) and High-Performance Jet Aircraft (HPJA) often experience musculoskeletal (MSK) pain as a result of heavy vibrational and g-loading, abrupt head maneuvering, and extensive flight hours.
- The prevalence of neck pain among military aviators is as high as 95% and is a top-10 aeromedical concern by the United States Navy.
- Like other MSK injuries, weakness and flexibility deficits are hypothesized to contribute to cervical spinal injuries.
- Advanced helmet-based systems introduce further risk, especially those that require the pilot to turn their head.
- A few studies around the world describing small scale success but no universal recommendation for combating this risk

## Aims

- Implement a regular exercise program using a portable c-spine resistance band system (NeckX™) in order to:
  - (1) Improve neck flexibility, strength, stiffness and pain
  - (2) Increase neck range of motion and endurance in military aviators



Figure 1: Check-six position with canopy raised, used to spot tailing aircraft

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## Cervical Spine Exercise Protocol:

### 1. Baseline anthropometrics

### 2. Measurements

- Obtain at baseline, 3 weeks, 6 weeks
- Questionnaires obtained weekly.

### 2. Warm Ups

- Neck Extension: 10 reps x 1 set
- Side Bending (L and R): 5 reps x 1 set
- Neck Rotation (L and R): 5 reps x 1 set
- Neck Flexion: 10 reps x 1 set

### 3. Stretches

- Neck Extension: 10 reps x 2 sets
- Side Bending (L and R): 10 reps x 2 sets
- Neck Rotation (L and R): 10 reps x 2 set
- Neck Flexion: 10 reps x 2 sets

### Optional Exercises (added on after prior)

- 45° Check to Back: 10 reps x 2 sets
- 45° Check to Down: 10 reps x 2 sets
- Vertical Lifts: 10 reps x 2 sets

### Guidelines:

- Perform 5 days/week.
- Begin with yellow band, then progress weekly (green then purple) as tolerated.
- After the third week, increase to 15 reps x 2 sets; add optional exercises if desired.

## Methods

### Notes:

- Pilot Study performed initially for feasibility (n = 10 F/A-18 Fixed-Wing HPJA aviators)
- Subjects were pulled from active-duty DoD personnel as well as civilians as the Houston Veterans Affairs Medical Center
- Upon completion, subjects were asked to rate the effectiveness and ease of use of the device and protocol.

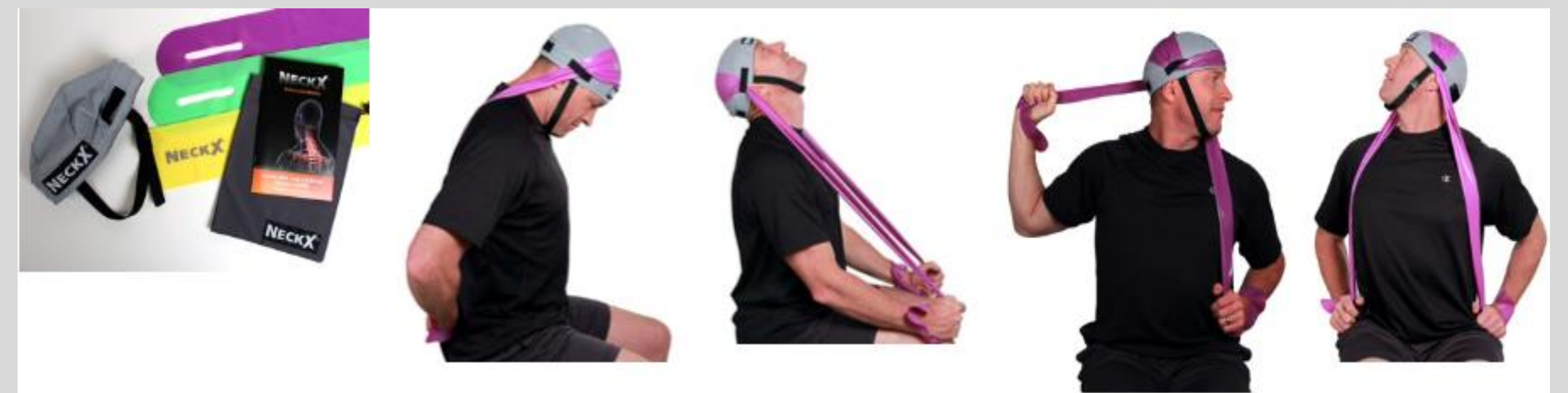


Figure 2: Portable Lightweight Exercise Device (PLED)[Neck-X(™)] being employed during exercise training.

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## Intake Questionnaire

Prevalence of neck pain in DoD flight crew in different scenarios

Question	Yes	No
<i>During the last 6 months, have you experienced neck pain UNRELATED to flying?</i>	10	4
<i>During the last 6 months have you experienced neck pain RELATED to flying?</i>	6	8
<i>During the past 6 months, have you had significant neck pain DURING flight?</i>	5	9
<i>During the last 6 months, have you had significant neck pain AFTER flight?</i>	6	8
<i>During the last 6 months, have you had significant neck pain during flight that was related to equipment other than head-mounted systems?</i>	2	12
<i>Are there any flight maneuvers that consistently cause neck pain?</i>	3	11
<i>During the past 6 months, have you sought treatment for the occurrence of any flight related significant neck pain?</i>	3	11
<i>Have you ever been grounded as a result of flight-related neck pain?</i>	1	13
<i>Have you ever acted to minimize or avoid flight-related neck pain?</i>	2	12
<i>Used Night Vision Goggles (NVGs)?</i>	10	4

†Variables presented as total number of respondents.

Severity of neck pain episodes in DoD flight crew

Outcome Measure	Mild	Moderate	Severe	Very Severe	N/A
Severity of pain for the worst episode of pain experienced during last 6 months DURING flight	4	3	0	0	7
Severity of pain for the worst episode of pain experienced during last 6 months AFTER flight	3	5	0	0	6
Severity of pain for the typical episode of pain experienced during last 6 months DURING flight	4	3	0	0	7
Severity of pain for the typical episode of pain experienced during last 6 months AFTER flight	3	5	0	0	6

†Variables presented as total number of respondents.

Self-reported duration of pain during the worst and typical episodes during the previous 6 months

Outcome Measure	Worst Episode	Typical Episode
N/A	6	6
less than 2 hours after flight	0	2
2-11 hours after flight	2	1
12-24 hours after flight	3	3
1-4 days after flight	2	1
5+ days after flight	0	0
No Response	1	1

†Variables presented as total number of respondents.

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## Quantitative Results

### ROM Analysis, Pre- and Post-Intervention

Variable	Baseline	6-week follow-up	P-value
<i>Rotation, Left</i>	57.86 (13.55)	74.65 (9.42)	< 0.001*
<i>Rotation, Right</i>	58.94 (16.71)	74.90 (10.79)	< 0.001*
<i>Lateral, Left</i>	32.40 (10.63)	43.05 (9.72)	< 0.001*
<i>Lateral, Right</i>	30.34 (11.23)	40.11 (10.68)	< 0.001*
<i>Flexion</i>	32.13 (17.30)	42.32 (18.38)	< 0.001*
<i>Extension</i>	41.38 (16.61)	56.02 (15.81)	< 0.001*

†Variables presented as mean (SD), in degrees.

### Endurance Analysis, Pre- and Post-Intervention

Variable	Baseline	6-week follow-up	P-value
<i>Rotation, Left</i>	20.08 (17.46)	42.13 (21.87)	< 0.001*
<i>Rotation, Right</i>	18.50 (17.23)	43.79 (20.11)	< 0.001*
<i>Lateral, Left</i>	24.25 (24.16)	49.88 (34.25)	< 0.001*
<i>Lateral, Right</i>	23.79 (23.85)	50.21 (31.67)	< 0.001*
<i>Flexion</i>	23.96 (21.88)	53.29 (26.28)	< 0.001*
<i>Extension</i>	25.71 (23.15)	51.46 (29.95)	< 0.001*

†Variables presented as mean (SD), reported as number of repetitions before fatigue.

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## Quantitative Results

Comparison of Rotary-Wing (n=12) and Fixed-Wing (n=10) Aviators: Performance Changes Post-Intervention

Variable	Muscular Endurance		Cervical ROM	
	Rotary Wing	Fixed Wing	Rotary Wing	Fixed Wing
<i>Rotation</i>	+133.35%	+17.00%	+32.81%	+8.00%
<i>Lateral</i>	+78.38%	+10.00%	+40.66%	+7.00%
<i>Flexion</i>	+73.47%	+9.00%	+55.23%	+5.00%
<i>Extension</i>	+72.60%	+12.00%	+34.13%	+0.00%

†Variables presented as total number of respondents.

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## Qualitative Results with Comments

### Subjective Outcomes on Post-Intervention Follow-up

Outcome Measure	Vastly Improved	Slightly Improved	Same	Worsened
<i>Neck Flexibility</i>	6	15	2	0
<i>Neck Muscle Strength</i>	6	16	1	0
<i>Neck Stiffness</i>	6	12	5	0
<i>Neck Pain</i>	4	9	10	0

†Variables presented as total number of respondents.

- “We need immediate access to PT on the flight line”
- “The act of flying a helicopter isn excess of 2 hrs causes neck, shoulder, & upper back pain. The position I sit in the cockpit has a tendency to be leaning forward placing more strain on my upper back and neck.”
- “Good posture declines as you end up slouching or bent over due to "scope lock.””
- “It is/was routine for SH-60B and MH-60R AW to sit in twisted position during landings on RAST capable ships to assist pilot in positioning A/C over the trap. Landing in this position cannot be good for the neck and back.”

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## Discussion and Future Directions

- This study demonstrated statistically significant increases in cervical ROM and muscular endurance across all measures
- Most study participants reported varying levels of subjective improvements in neck flexibility, strength, stiffness, and pain
- Improvement across these measures may lead to increased mission success and decreased medical disqualifications
- This study was limited by the low total recruitment, low recruitment of female subjects, and low rates of follow-up due to deployments, TDYs and other operational requirements
- We look forward to collaborations with our colleagues at the U.S. Army Aeromedical Research Laboratory (USAARL) in and U.S. Air Force to push to create a service-wide recommendation in the future

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## References

- Alagha, B. (2015, October 01). Conservative Management of Mechanical Neck Pain in a Helicopter Pilot. *Aerospace Medicine and Human Performance*, 86(10), 907-910.
- Chumbley, E. M., O'Hair, N., Stolfi, A., Lienesch, C., McEachen, J. C., & Wright, B. A. (2016, December 1). Home Cervical Traction to Reduce Neck Pain in Fighter Pilots. *Aerospace Medicine and Human Performance*, 87(12), 1010-1015.
- Farrell, P. S., Shender, B. S., Goff, C. P., Baudou, J., Crowley, J., Davies, M., . . . Oor, v. d. (2020). *Aircrew Neck Pain Prevention and Management*. Technical Report, North Atlantic Treaty Organization, Science and Technology Organization.
- Ång, B. O., Monnier, A., & Harms-Ringdahl, K. (2009, July). Neck/Shoulder Exercise for Neck Pain in Air Force Helicopter Pilots: A Randomized Controlled Trial. *Spine*, 34(16), E544-E551.
- Green, B. N., Dunn, A. S., Pearce, S. M., & Johnson, C. D. (2010, June). Conservative management of uncomplicated mechanical neck pain in a military aviator. *Journal of the Canadian Chiropractic Association*, 54(2), 92-99.
- Keskimölä, T., Pernu, J., Karppinen, J., Niinimäki, J., Oora, P., Leino, T., & Honkanen, T. (2021, June 15). Degenerative cervical spine changes among early career fighter pilots: a 5-year follow-up. *BMJ Military Health*.
- Khan, R., Ryan, D., Keller, R., Reece, R., Khalid, R., & Jones, J. (2021, June 04). Risks and countermeasures for the musculoskeletal systems in the extreme environment of aviators and astronauts. *Journal of Physical Medicine and Rehabilitation*.
- Lange, B., Torp-Svendsen, J., & Toft, P. (2011, May 01). Neck Pain Among Fighter Pilots After the Introduction of the JHMCS Helmet and NVG in Their Environment. *Aviation, space, and environmental medicine*, 82(5), 559-63.
- MILITARY PILOT DEMOGRAPHICS AND STATISTICS IN THE US. (n.d.). Retrieved June 2022, from Zippia: <https://www.zippia.com/military-pilot-jobs/demographics/>
- Moon, B. J., Choi, K. H., Yun, C., & Ha, Y. (2015, May 1). Cross-Sectional Study of Neck Pain and Cervical Sagittal Alignment in Air Force Pilots. *Aerospace Medicine and Human Performance*, 86(5), 445-451.
- Mulay, R., Gangwal, A., Shyam, A., & Sancheti, P. (2019, June). Prevalence and risk factors for work related musculoskeletal disorders in flight attendants. *International Journal Of Community Medicine And Public Health*, 6(6), 2456-2459.
- Murray, M., Lange, B., Søgaard, K., & Sjøgaard, G. (2020, November 23). The Effect of Physical Exercise Training on Neck and Shoulder Muscle Function Among Military Helicopter Pilots and Crew: A Secondary Analysis of a Randomized Controlled Trial. *Frontiers in Public Health*, 8.
- Netto, K., Hampson, G., Opperman, B., Carstairs, G., & Aisbett, B. (2011, January). Management of neck pain in Royal Australian Air Force fast jet aircrew. *Military Medicine*, 176(1), 106-109.
- Posch, M., Schranz, A., Lener, M., Senn, W., Ång, B. O., Burtscher, M., & Ruedl, G. (2019, January 29). Prevalence and potential risk factors of flight-related neck, shoulder and low back pain among helicopter pilots and crewmembers: a questionnaire-based study. *BMC Musculoskeletal Disorders*, 20(1).
- Rintala, H., Häkkinen, A., Siitonen, S., & Kyröläinen, H. (2015, December 01). Relationships Between Physical Fitness, Demands of Flight Duty, and Musculoskeletal Symptoms Among Military Pilots. *Military Medicine*, 180(12), 1233-1238.
- Rintala, H., Sovelius, R., Rintala, P., Huhtala, H., Siitonen, S., & Kyröläinen, H. (2017, September 25). MRI findings and physical performance as predictors of flight-induced musculoskeletal pain incidence among fighter pilots. *Biomedical Human Kinetics*, 9(1), 133-139.
- Sawyer, S. (2020, February 16). Reinstated pilot first to fly F-15 Eagle with cervical prosthetic disc.
- Shiri, R., Frilander, H., Sianio, M., Karvala, K., Sovelius, Roope, . . . Viikari-Juntura, E. (2015, February). Cervical and lumbar pain and radiological degeneration among fighter pilots: a systematic review and meta-analysis. *Occupational and Environmental Medicine*, 72(2), 145-150.
- Sovelius, R., Salonen, O., Lamminen, A., Huhtala, H., & Hämäläinen, O. (2008, July). Spinal MRI in fighter pilots and controls: a 13-year longitudinal study. *Aviation, Space, and Environmental Medicine*, 79(7), 685-688.
- Tegern, M., Aasa, U., Ång, B. O., & Larsson, H. (2020, May 14). Musculoskeletal disorders and their associations with health- and work-related factors: a cross-sectional comparison between Swedish air force personnel and army soldiers. *BMC Musculoskeletal Disorders*, 21(1).
- Yang, Y., Liu, S., Ling, M., & Ye, C. (2022, January 04). Prevalence and Potential Risk Factors for Occupational Low Back Pain Among Male Military Pilots: A Study Based on Questionnaire and Physical Function Assessment. *Frontiers in Public Health*, 9.