

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Jeffrey A. Jones^{1,2}, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O'Connor¹, Daphne Ryan⁵ Vignesh Ramachandran¹

¹Baylor College of Medicine, Center for Space Medicine, Houston, TX, ²Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division NAWCAD), Patuxent River, MD, ⁴United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵Naval Air Station Whidbey Island, Oak Harbor, WA



VA



U.S. Department of Veterans Affairs

Veterans Health Administration
Michael E. DeBakey VA Medical Center

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

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O'Connor¹, Daphne Ryan⁵, Vignesh Ramachandran¹, Jeffrey A. Jones^{1,2}

¹ Baylor College of Medicine, Center for Space Medicine, Houston, TX, ² Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³ Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division NAWCAD), Patuxent River, MD, ⁴ United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵ Naval Air Station Whidbey Island, Oak Harbor, WA



VA



U.S. Department of Veterans Affairs

Veterans Health Administration
Michael E. DeBakey VA Medical Center

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.

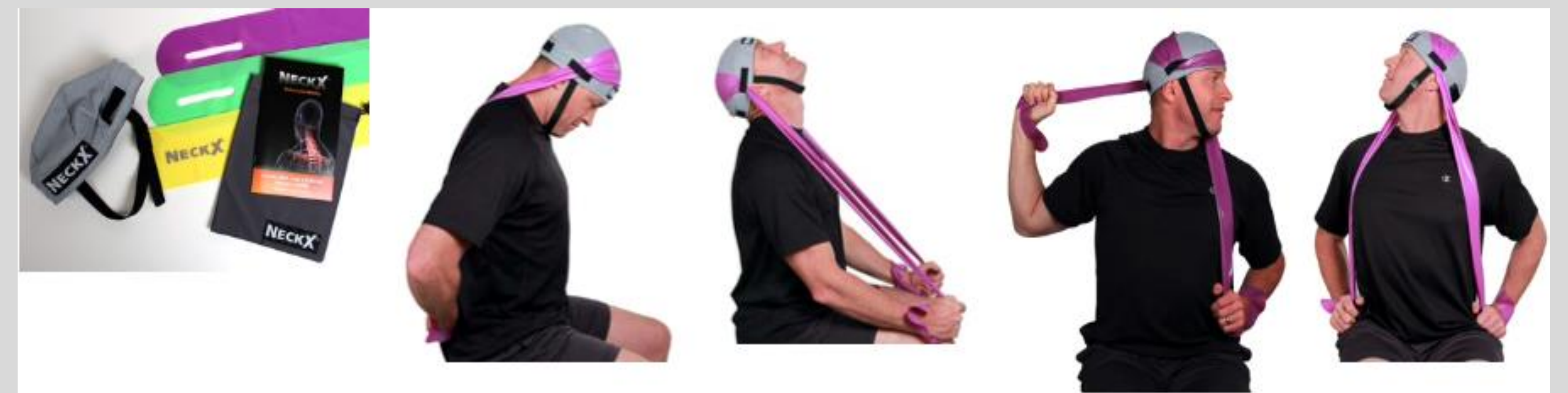


Figure 2: Portable Lightweight Exercise Device (PLED)[Neck-X(™)] being employed during exercise training.

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O’Conor¹, Daphne Ryan⁵ Vignesh Ramachandran¹, Jeffrey A. Jones^{1,2}

¹ Baylor College of Medicine, Center for Space Medicine, Houston, TX, ² Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³ Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division NAWCAD), Patuxent River, MD, ⁴ United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵ Naval Air Station Whidbey Island, Oak Harbor, WA



VA



U.S. Department of Veterans Affairs
Veterans Health Administration
Michael E. DeBakey VA Medical Center

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.

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O’Conor¹, Daphne Ryan⁵ Vignesh Ramachandran¹, Jeffrey A. Jones^{1,2}

¹ Baylor College of Medicine, Center for Space Medicine, Houston, TX, ² Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³ Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division NAWCAD), Patuxent River, MD, ⁴ United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵ Naval Air Station Whidbey Island, Oak Harbor, WA



VA



U.S. Department of Veterans Affairs
Veterans Health Administration
Michael E. DeBakey VA Medical Center

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.

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O’Conor¹, Daphne Ryan⁵ Vignesh Ramachandran¹, Jeffrey A. Jones^{1,2}

¹ Baylor College of Medicine, Center for Space Medicine, Houston, TX, ² Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³ Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division NAWCAD), Patuxent River, MD, ⁴ United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵ Naval Air Station Whidbey Island, Oak Harbor, WA



VA

U.S. Department of Veterans Affairs
Veterans Health Administration
Michael E. DeBakey VA Medical Center

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.

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O’Conor¹, Daphne Ryan⁵ Vignesh Ramachandran¹, Jeffrey A. Jones^{1,2}

¹ Baylor College of Medicine, Center for Space Medicine, Houston, TX, ² Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³ Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division NAWCAD), Patuxent River, MD, ⁴ United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵ Naval Air Station Whidbey Island, Oak Harbor, WA



VA



U.S. Department of Veterans Affairs
Veterans Health Administration
Michael E. DeBakey VA Medical Center

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.”

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O'Connor¹, Daphne Ryan⁵, Vignesh Ramachandran¹, Jeffrey A. Jones^{1,2}

¹ Baylor College of Medicine, Center for Space Medicine, Houston, TX, ² Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³ Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division NAWCAD), Patuxent River, MD, ⁴ United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵ Naval Air Station Whidbey Island, Oak Harbor, WA



VA



U.S. Department of Veterans Affairs

Veterans Health Administration
Michael E. DeBakey VA Medical Center

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

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

Ryan J. Keller¹, Reece Rosenthal¹, Sawan Dalal¹, Bethany Shivers^{3,4}, Barry Shender³, Brian Novotny⁴, Sheryl Vandeven², Nicole Butler¹, Daniel O'Connor¹, Daphne Ryan⁵, Vignesh Ramachandran¹, Jeffrey A. Jones^{1,2}

¹ Baylor College of Medicine, Center for Space Medicine, Houston, TX, ² Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, ³ Naval Air Systems Command (NAVAIR) Naval Air Warfare Center, Aircraft Division (NAWCAD), Patuxent River, MD, ⁴ United States Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, ⁵ Naval Air Station Whidbey Island, Oak Harbor, WA



VA



U.S. Department of Veterans Affairs

Veterans Health Administration
Michael E. DeBakey VA Medical Center

Acknowledgements

- All aircrew who participated freely and gave their time for completing surveys and protocols
- NAWCAD for financial support
- All fellow flight surgeons, aerospace physiologists (AMSOs), and Physical Therapists for their work in recruiting and administering the protocol
- Baylor College of Medicine, Center for Space Medicine

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., Siano, 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.