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Predicting Neck Pain in Royal Australian Air Force Fighter Pilots

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ABSTRACT Objective: Fighter pilots frequently report neck pain and injury, and although risk factors have been suggested, the relationships between risk factors and neck pain have not been quantified. The aim of this study was to identify personal and work behaviors that are significantly associated with neck pain in fighter pilots. Methods: Eighty–two Royal Australian Air Force fighter pilots were surveyed about their flying experience, neck pain prevalence, and prevention. Multinomial logistic regressions were used to fit models between pilots' neck pain during and after flight and a range of personal and work characteristics. Results: In-flight neck pain was very weakly, yet positively associated with flight hours. Duration of postflight pain was positively associated with the weekly desktop work hours and the sum of preventative actions taken in flight. The duration pilots were considered temporarily medically unfit for flying was positively associated with pilots' age and their weekly desktop work hours. Discussion: The risk factors identified by the current study should guide neck pain prevention for fighter pilots. In particular, reducing desktop working hours as well as incorporating specific neck-strengthening exercises and in-flight bracing actions should be considered by agencies to help alleviating neck pain in their pilots.

INTRODUCTION

High-performance combat (i.e., "fighter") pilots are critical in maintaining the integrity and safety of a nation's airspace. Fighter pilots perform many maneuvers, such as, rolls, turns, and climbs, while flying.[1] These maneuvers are fundamental for both defense and offense against enemy aircraft.[2] While executing these maneuvers, the aircraft and the fighter pilot's body are exposed to forces equivalent to up to eight times that of gravity (i.e., +8 Gz).[2] Fighter pilots also have a number of duties while on the ground, including mission planning, briefings and debriefings as well as preparing materials and other miscellaneous administration tasks.[3]

There are numerous reports of fighter pilots suffering from cervical spine injuries, with the most common being strains or stiffness of the neck muscles.[2,4] In Australia and the United States, 85% of F/A 18 fighter pilots reported having experienced neck pain during their flying careers.[1,5] Their neck injuries can be categorized into two main subgroups[6]: acute neck injuries, which occur during or shortly after flight, and chronic neck injuries, which develop over time. In addition to the obvious health consequences, neck injuries can interfere with pilots' flying performance, concentration levels, situational awareness, and potentially the safety of themselves and their squadron.

To limit pilot's risk of injury and the consequences of existing injury, they maybe deemed temporarily medically unfit for flying (TMUFF) if they report neck pain.[7] In a recent survey, 34/82 Royal Australian Air Force (RAAF) pilots had been classified TMUFF because of neck pain with the average length of time being less than a week.[7] Given the importance of maintaining pilot numbers and performance for airspace capability, determining which factors are implicated in the pilot's neck pain can guide prevention and management strategies to limit TMUFF periods. Existing research suggests that flying hours, desktop work hours, and exercise are all implicated in neck pain (or injury).[2,3,8] No studies have quantified the relationship between these factors and neck pain/TMUFF in fighter pilots. Therefore, the aim of this study was to identify significant associations between personal characteristics such as flight hours, behavior such as the amount of exercise and neck pain during and after flight. These associates were investigated for the duration of worst and average pain levels as well as the duration that fighter pilots were considered TMUFF. These associations can then be thought of as "predictors" or "risk factors" for neck pain in high-performance combat pilots.

METHODS

Participants

The aim and purpose of this study with a brief description of the methodology were explained to all aircrew. All information was treated with strictest Study-In-Confidence and was not used to initiate medical treatment or Medical Employment Classification Review proceedings.

Eligible aircrew were current permanent or reserve RAAF aircrew (pilot, navigator and flight test engineers) either presently or previously qualified on a high-performance airframe, including students presently undergoing a conversion course onto a high-performance aircraft. For the purpose of this study, they were grouped together as one cohort. Personnel from foreign military organizations were excluded from this study as long-term follow-up (as part of a larger RAAF study) was expected to be problematic. All procedures were

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Survey Instrument

The survey comprised 18 questions and was divided into six sections. These six sections broadly surveyed personal details and flying experience (section one), helmets and night vision goggles/helmet-mounted display systems usage (section two), preventative activities while flying to minimize the risk of neck pain and injury (section three), neck strain, pain or injury sustained (section four), neck pain management (section five), and neck pain prevention while flying (section six). Only sections one, three, four, and six were used in the study. Section one of the survey queried general information of the participants including self-reported anthropometry, flying history in hours, and the type of aircraft in which this experience was gained. Section three of the survey assessed the number of preventative actions used by the participants to minimize neck pain and injury during and after flight (Table I). Section four queried the existence of flight-related neck pain, the severity of such pain on a visual analogue scale of 0 (no pain) to 10 (worst possible pain), and the duration of the pain experienced postflight. Both the levels of pain severity and duration were surveyed for the worst and average episodes of flight-related neck pain experienced by the participant. The length of time the participants were TMUFF was also measured in this section. Section six investigated the amount of times the participants performed aerobic, resistance, and neck-specific exercises as well as any other neck pain prevention strategies conducted.

Data Analyses

The data were separated into dependent and independent variables. The dependent variables measured were "number of neck pain episodes during flight," "number of neck pain episodes after flight," "duration of worst episode," "duration of average episode," and "longest duration of TMUFF." The categories for each variable are summarized in Table II.

TABLE I. List of Preventative Actions

Number	Preventative Action
1	Preflight neck stretching
2	In-flight Gz warm-up
3	Set head position before application of Gz
4	Restrict movement under Gz, move only under low Gz
5	Move upper body as well as head/neck
6	Use shoulders to aid rotation of head
7	Keep head aligned with body under Gz
8	Brace head against aircraft canopy
9	Brace head against ejection seat head box
10	Move head/neck in only one plane under Gz
11	Minimize overall exposure to Gz
12	Postflight neck stretch

TABLE II. Dependent Variable Categories

Dependent Variable and Category	Category Number and Description
No. of Neck Pain Episodes During and After Flight	0, No Pain
	1, 1–3 Episodes
	2, 4–10 Episodes
	3, >10 Episodes
Duration Worst and Average Pain	0, No Pain
	1, <12 Hours
	2, 12–24 Hours
	3, 24–96 Hours
	4, >96 Hours
Longest Continuous TMUFF	0, Never
	1, <1 Week
	2, 1–2 Weeks
	3, 3–4 Weeks
	4, >1 Month

TABLE III. Exercise Categories

Category Number	Description
0	Never
12	Once a Month
24[a]	1–3 Times a Month
52	Once a Week
156[b]	2–5 Times a Week
365	Once a Day

[a]The middle value of 2 was used (2 × 12 months = 24).
[b]Middle value of 3 was used (3 × 52 weeks = 156).

The independent variables included were flight hours, age and height, the amount of exercise, the amount of preventative actions, and the amount of desktop hours. Independent variables also included the frequency with which participants performed aerobic, anaerobic, and neck exercises in a calendar year, which were categorized into groups (Table III). The number of preventative actions used by the pilots reflected a sum of all the actions out of 12, taken from the survey. For example, a value of "7"; means that a respondent used 7 of the 12 available actions. For a full list of the preventative actions, please refer to Table I.

Statistics

Multinominal logistic regressions were used in the current study since each dependent variable was categorical and had more than 2 outcomes.[9] Backward stepwise regressions were performed since the study was exploratory in nature and to limit the chances of a type II error.[9] Parameter estimates were used to establish the relationship between the independent and dependent variables, whereas odds ratios quantified the likelihood that a one unit increase in the independent variable would significantly change the dependent variable (compared to baseline).[9] Significance level for all analyses was set at $p < 0.05$, with all data analysis being conducted with Statistical Package for Social Sciences V.17.0 (IBM SPSS, Champaign, Illinois). All descriptive data are expressed as means ± SDs unless otherwise stated.

RESULTS

Eighty-two male pilots (31 ± 7 years, 180.6 ± 6.5 cm, 81.1 ± 8.6 kg, 2,013 ± 1,570 flying hours) responded to the survey. This is a response rate of approximately 96%. Descriptive data from the survey regarding the frequency, duration, and management of neck pain in fighter pilots were presented in a previous article.[7]

Number of Neck Pain Episodes During Flight

The model significantly predicted the number of neck pain episodes during flight ($p = 0.005$). The model included flight hours ($p = 0.005$) and excluded desktop hours ($p = 0.5450$), height ($p = 0.323$), anaerobic exercise ($p = 0.759$), neck exercise between flights ($p = 0.307$), aerobic exercise ($p = 0.310$) frequencies, preventative actions ($p = 0.228$), and age ($p = 0.250$). The relationship between the number of flight hours and the likelihood of increasing the number of in-flight pain episodes from none to 1–3, 4–10, and >10, respectively, is presented in Table IV. As shown, an increase of flight hours was associated with a significant increase in the likelihood of pilots experiencing 4–10 pain episodes and >10 pain episodes in flight (compared to no pain). The odds ratio for this relationship was 1.001, which indicates that for a 1-hour increase in flight time, the odds of the pilots suffering >4 episodes in flight, compared to no pain, would increase by 0.001 ($p = 0.010$).

TABLE IV. Odds Ratio Table for Number of Neck Pain Episodes During and After Flight

	B (SE)	Odds Ratio (95% CI)
Neck Pain During Flight		
1–3 Episodes		
Intercept	−0.16 (0.569)	
Flight Hours	0.001 (0.000)	1.001 (1.000–1.001)
4–10 Episodes		
Intercept	−1.055 (0.628)	
Flight Hours	0.001 (0.000)*	1.001 (1.000–1.002)
>10 Episodes		
Intercept	−0.911 (0.616)	
Flight Hours	0.001 (0.000)*	1.001 (1.000–1.002)
Neck Pain After Flight		
1–3 Episodes		
Intercept	−0.556 (0.960)	
Neck Exercise	−0.007 (0.004)	0.993 (0.985–1.002)
Flight Hours	0.000 (0.000)	1.000 (0.999–1.000)
Preventative Actions	0.406 (0.198)*	1.501 (1.019–2.211)
4–10 Episodes		
Intercept	−1.808 (1.148)	
Neck Exercise	−0.008 (0.005)	0.992 (0.983–1.002)
Flight Hours	0.000 (0.000)	1.000 (1.000–1.001)
Preventative Actions	0.374 (0.218)	1.454 (0.948–2.230)
>10 Episodes		
Intercept	−2.389 (1.132)	
Neck Exercise	0.000 (0.004)	1.000 (0.993–1.008)
Flight Hours	0.000 (0.000)	1.000 (1.000–1.001)
Preventative Actions	0.486 (0.207)*	1.626 (1.084–2.439)

B = Beta Coefficient, SE = Standard Error, CI = Confidence Interval. *$p < 0.05$.

Number of Neck Pain Episodes After Flight

The model significantly predicted the number of neck pain after flight ($p = 0.003$). It included neck exercise between flights ($p = 0.041$) and excluded flight hours ($p = 0.084$) and preventative actions in flight ($p = 0.080$), anaerobic exercise ($p = 0.789$), aerobic exercise ($p = 0.669$) frequencies, height ($p = 0.435$), age ($p = 0.376$), and desktop hours ($p = 0.342$). The relationship between the number of neck pain episodes after flight and the likelihood of increasing the number of postflight neck pain episodes from none to 1–3, 4–10, >10, respectively, is presented in Table IV. As shown, neck exercise training frequency could not predict categories of postflight neck pain.

Duration of Worst Pain Episode

The model significantly predicted the duration of worst pain episode ($p < 0.001$). It included flight hours ($p = 0.001$) and desktop hours ($p = 0.011$) and excluded anaerobic exercise ($p = 0.857$), neck exercise between flights ($p = 0.492$), aerobic exercise ($p = 0.345$) frequencies, age ($p = 0.361$), height ($p = 0.243$) and preventative actions ($p = 0.203$). The relationship between the number of flight and desktop hours and the likelihood of increasing the duration of worst neck pain is presented in Table V. As shown, an increase in desktop hours was associated with a significant increase in the likelihood of the duration of worst pain episode lasting >12 hours. The odds ratios for the worst pain lasting <12 hours, 12 to 24 hours, 24 to 96 hours, and >96 hours are 251.3, 295.2, 331.7, and 335.4, respectively. These ratios indicate that for a 1-hour increase in desktop hours, the odds that the duration of worst pain will last at least <12 hours increases by approximately 250 times, with higher odds for pain lasting longer than 12 hours (Table V).

Duration of Average Pain Episode

The model significantly predicted the duration of average pain episode ($p = 0.001$). It included flight hours ($p = 0.006$) and preventative actions ($p = 0.039$) and excluded desktop hours ($p = 0.979$), height ($p = 0.605$), neck exercise between flights ($p = 0.692$), anaerobic exercise ($p = 0.510$), aerobic exercise ($p = 0.943$) frequencies, and age ($p = 0.231$). The relationships between the number of flight hours and the number of preventative actions used in flight and the likelihood of increasing the duration of average pain episode are presented in Table V. As shown, an increase in preventative actions was associated with a significant increase in the likelihood that average pain episode will last between 12 and 96 hours. The odds ratios for <12 hours, 12 to 24 hours, 24 to 96 hours, and >96 hours are 1.8, 2.0, 1.8, and 2.0, respectively. These ratios indicate that increasing the sum of preventative

TABLE V. Odds Ratio Table for Duration of Worst and Average Pain Episodes

	B (SE)	Odds Ratio (95% CI)
Duration Worst		
<12 Hours		
Intercept	−1.933 (1.173)	
Flight Hours	0.002 (0.002)	1.002 (0.999–1.005)
Desktop Hours	5.527 (0.173)*	251.324 (179.148–352.580)
12–24 Hours		
Intercept	−1.1573 (1.158)	
Flight Hours	0.002 (0.002)	1.002 (0.999–1.005)
Desktop Hours	5.688 (0.168)*	295.237 (212.237–410.040)
24–96 Hours		
Intercept	−2.542 (1.193)	
Flight Hours	0.003 (0.002)	1.003 (1.000–1.006)
Desktop Hours	5.804 (0.131)*	331.714 (256.568–428.870)
>96 Hours		
Intercept	−2.996 (1.193)	
Flight Hours	0.003 (0.002)*	1.003 (1.000–1.006)
Desktop Hours	5.815 (0.000)*	335.409 (335.409–335.409)
Duration Average		
<12 Hours		
Intercept	−1.217 (1.066)	
Flight Hours	0.000 (0.000)	1.000 (0.999–1.000)
Preventative Actions	0.565 (0.231)*	1.759 (1.118–2.766)
12–24 Hours		
Intercept	−2.124 (1.248)	
Flight Hours	0.000 (0.000)	1.000 (0.999–1.000)
Preventative Actions	0.681 (255)*	1.976 (1.198–3.260)
24–96 Hours		
Intercept	−2.080 (1.134)	
Flight Hours	0.000 (0.000)	1.000 (1.000–1.001)
Preventative Actions	0.569 (0.232)*	1.766 (1.121–2.782)
>96 Hours		
Intercept	−5.124 (1.797)	
Flight Hours	0.001 (0.000)	1.001 (1.000–1.001)
Preventative Actions	0.698 (0.287)*	2.010 (1.145–3.528)

*$p < 0.05$.

TABLE VI. Odds Ratio Table for Duration Longest Continuous TMUFF

	B (SE)	Odds Ratio (95% CI)
Duration TMUFF		
<1 Week		
Intercept	4.035 (9.621)	
Age	0.138 (0.048)*	1.148 (1.05–1.26)
Height	−0.055 (0.053)	0.946 (0.85–1.05)
Neck Exercise	0.001 (0.003)	1.001 (1.00–1.001)
Anaerobic Exercise	−0.007 (0.005)	0.993 (0.98–1.00)
Preventative Actions	−0.058 (0.150)	0.944 (0.70–1.27)
Desktop Hours	0.471 (176)*	1.602 (1.14–2.26)
1–2 Weeks		
Intercept	−3.898 (19.261)	
Age	0.172 (0.086)	1.187 (1.19–1.41)
Height	−0.053 (0.103)	0.948 (0.95–1.16)
Neck Exercise	0.008 (0.006)	1.008 (1.01–1.02)
Anaerobic Exercise	0.013 (0.009)	1.013 (1.01–1.03)
Preventative Actions	0.457 (0.285)	1.58 (1.58–2.76)
Desktop Hours	0.116 (0.281)	1.123 (1.12–1.95)

*$p < 0.05$

actions in flight, from 7 to 8 for example, doubles the odds that the average pain episodes will last from 12 to 24 hours or >96 hours, compared to no pain. The amount of flight hours flown by the pilots was unable to predict the pain duration categories (Table V).

Duration of Longest Continuous TMUFF

The model significantly predicted the duration of longest continuous TMUFF ($p = 0.001$). It included age ($p = 0.001$), height ($p < 0.001$), neck exercise between flights ($p < 0.001$), anaerobic exercise ($p = 0.004$) frequencies, preventative actions ($p = 0.013$), and desktop hours ($p = 0.001$). It excluded flight hours ($p = 0.584$) and aerobic exercise frequency ($p = 0.229$). The relationships between age, height, neck exercise between flights, anaerobic exercise, preventative actions, and desktop hours and the likelihood of increasing the duration of longest continuous TMUFF are presented in Table VI. As shown, an increase in age and desktop hours was associated with a significant increase in the likelihood that the pilots were TMUFF for <1 week. The odds ratios of 1.15 for age indicates that for every 1 year added to the age of the pilots, the odds of the pilots being declared TMUFF for <1 week increased by 1.15. The odds ratio of 1.6 for desktop hours indicates that the pilots being declared TMUFF <1 week increased by 1.6 for every 1-hour increase in their desktop hours. Finally, the height of the pilots, the frequency of neck and anaerobic exercises, and preventative actions were unable to predict categories of TMUFF duration.

DISCUSSION

The purpose of this study was to identify significant predictors of neck pain in RAAF fighter pilots. Participant's flight hours predicted their number of neck pain episodes during flight, whereas their flight hours, the frequency with which they performed neck exercise between flights, and the sum of preventative actions they performed in flight predicted neck pain after flight. The duration of participant's worst pain episode was predicted by their flight hours and their weekly desktop work hours, whereas the duration of their average pain episode was predicted by their flight hours and their use of preventative actions in flight. Further, the duration of participant's longest continuous TMUFF was predicted by participant's age, height, the frequency with which they performed neck and resistance exercises, the sum of the preventative actions they performed in flight, and the amount of desktop hours they worked in a week.

An increase in the number of flight hours that the participants accrued was significantly associated with an increase of neck pain during flight and the duration of the worst pain episode postflight. However, in both cases, these were very weak associations. This is contrary to De Loose et al[3] who reported that the quantity of F-16 flight hours had no influence on the occurrence of neck pain. The current study measured flight hours in terms of total flying hours not just those performed in a specific aircraft, as specified by De Loose et al.[3] It is possible that if De Loose et al[3] included all their pilots' flying hours, their results may have been different. The findings of the current study, however, concur with the observations of Albano and Stanford[2] who found that flight hours, although not statistically significant, had a weak relationship with neck pain. The likely mechanism behind the relationship between flight hours and neck pain may be the repeated exposure to high gravitational forces in flight.[10] These forces can alter the head–neck segment biomechanics and may explain, at least in part, the neck pain (and possible injury) in fighter pilots.[11] The significant relationship identified in the current study, though very weak could inform future investigations into the relationships between exposure to specific Gz forces in flight and neck pain.

The current study found that an increase in neck pain after flight was significantly associated with a decreased frequency of performing neck exercise between flights. This result infers that a decrease in neck exercise training during the week may lead to increased pain after flight. This finding supports the premise of the utility of neck-specific conditioning exercises in this occupational group. Ang et al[12] reported that a significant decrease in the prevalence of neck pain in 68 Swedish helicopter pilots, following a neck exercise intervention.[4] As the current study used a retrospective design, it cannot be ruled out that those fighter pilots with existing neck pain postflight participate in less neck exercise to not exacerbate the pain in later flights. Interestingly, a very weak, yet significantly positive relationship was identified between the duration of TMUFF and the frequency of neck-strengthening exercises performed between flights (Table VI). Though this result could infer that more neck-specific training increases the duration of TMUFF, it is equally plausible that pilots on TMUFF perform more neck strengthening during this period in an effort to rehabilitate. Again, the retrospective study design limits the identification of causal relationships. A randomized control trial investigating the effect of neck-specific training in the reduction of neck pain in this occupational cohort should be trialed to identify the value (or not) of neck exercise training and neck pain in fighter pilots.

Postflight neck pain was significantly associated with the frequency of neck-specific training and flight hours, yet neither variable could distinguish between the levels of pain postflight (compared to no pain) *or TMUFF*. One suggestion for this result could be due to the influence of large between-participant variation. Regression and correlation analyses seek to identify linear relationships between 2 (or more) variables. The likelihood of identifying linear relationships improved when examining data sets with large between-participant variation.[13] In contrast, more homogenous data, with smaller between-participant variation, such as parameter estimates comparing each outcome category to baseline, are more difficult to identify linear relationships.[13]

The duration of pilot's average pain was positively associated with the number of preventative actions they performed during flight. On first inspection, it is surprising that an increase in the number of preventative actions would be significantly associated with an increase in the length of average postflight pain. These actions include restricting movement under Gz, moving only under low Gz, bracing the head against aircraft canopy, and bracing the head against the ejection seat head box.[7] It is possible that since these movements involve substantial activation of the neck musculature, they put further stress on these muscles, causing them to becoming even more fatigued.[4] Muscle fatigue has been suggested as a risk factor for neck injuries as it interferes with muscle coordination,[4] which could in turn, increase the risk of neck pain. An alternatively explanation for this finding may be that pilots who already experience neck pain, make more use of these techniques in the hope of protecting their already vulnerable neck. Because of the design of the current study, however, cause and effect cannot be resolved so it is unclear whether preventative actions cause or exacerbate existing pain or are merely associated with longer postflight pain through another yet to be identified mechanism. To find the answer to this question, a randomized control trial comparing pain levels for one group performing preventative actions in flight and the other not performing preventative actions in flight could be undertaken. The practicalities of such a trial for both experimental and control group members would, however, need careful consideration.

The current study found that the amount of desktop hours per week performed by the pilots was positively and significantly associated with an increase in the duration of their worst neck pain episodes postflight. This finding supports existing research showing work-related neck disorders are common in office workers, particularly those who have high computer usage time.[14] De Loose et al[15] studied military office workers and showed that sufferers of neck pain within this population conducted significantly more computer working time.[15] Although desktop activities and neck pain are a common association, the specific origin of neck pain, be it posture, stress levels, or physical health,[16] is not known, making targeted interventions difficult. However, a direct consequence from the result of the current study may be to decrease pilots' weekly desktop hours. This may be beneficial (irrespective of the mechanism) in alleviating neck pain.

The current study found that the pilot's length of continuous TMUFF status was positively associated with their age. The positive relationship between age and length of TMUFF (self or Aviation Medical Officer imposed) is likely to be mediated by pain or injury.[7] From a review of the neck pain literature, McLean et al[17] showed that there is strong evidence to suggest that in the general population, people in the age range of 45 to 55 years were twice as likely to develop neck pain compared to their younger counterparts.[17] There are a number of different mechanisms that could account for the increase in pain with increasing age, with some authors suggesting that the increase in pain with age may be due to the increasing degeneration of the cervical spine with age.[18] The decrease in mobility and strength of the spine, and the degeneration of the facet joints,[19] could also cause the increase in pain and injury in older fighter pilots. Also, longer periods of TMUFF for older pilots could reflect their decreased ability to recover from the injury compared to their younger counterparts.[19] The combination of increased vulnerability to injury and slower healing may contribute to the increased weakness and fatigability of neck muscles in older fighter pilots,[19] which would prolong TMUFF.

The results of the current study show that both aerobic and resistance training frequency were not significantly associated with predicting neck pain or TMUFF time in fighter pilots. This is contrary to previous literature, which suggests whole-body strength training as a possible preventative mechanism for mechanical neck disorders.[2,20,22] Similarly, Oldervoll, et al[23] showed that aerobic training sessions significantly reduced neck muscle pain in hospital staff after 8 weeks of training.[23] It is possible that fighter pilots, by virtue of their high risk for neck pain, require more specific conditioning than other populations, as suggested by the negative relationship between neck pain and neck strength training frequency (Table IV) Alternatively, the current findings could reflect limitations in the study design as the training used by pilots in the current study were self reported and not measured; only the frequency of exercise was surveyed. The survey instrument used did not ask the pilots to record the intensity of the training sessions. Without capturing a range of pertinent training variables (frequency, intensity, time, and type), it is difficult to assess training effectiveness and whether such training is related to neck pain. Future studies should try and capture intensity of training by incorporating rating of perceived exertion and training time into their survey tools.

Neck-specific conditioning interventions should be trialed by these agencies as this type of conditioning has been found to be effective in decreasing injury and pain in fighter pilots.[2] An increase in the rest periods or an alternate flying schedule for older pilots or those with increased exposure to flight and Gz, such as those with higher flight hours (>3,000), while operationally impractical could also be trialed. Given that desktop hours is a significant factor for neck pain and TMUFF in fighter pilots, a reduction in this type of work would be very beneficial to fighter pilots around the world. A possible method for reducing these hours is to engage administrative assistants to assist pilots with completing their designated paper work, wherever possible. Although hiring new staff may be costly, the authors believe these costs are insignificant compared to the cost associated with TMUFF fighter pilots and the rehabilitation costs once these injures have been sustained.

The current survey was conducted at a single time point, making cause and effect difficult to infer as the nominated dependent and independent variables in this study may have been interacting in the opposite directions. For example, existing neck pain may have caused pilots to increase their frequency of bracing to limit further damage. The current study also overfitted the regression model with more independent variables than commonly suggested for a sample size of 82 respondents.[9] The authors feel, however, that with such a valuable and specialized cohort, violations of the ratio of respondents to independent variables should not undervalue the results of the current study. Future studies should be directed at investigating discrete time points in fighter pilot work, for example, analyses of the effect of preceding desktop work or exercise to flying should be performed.

Fighter pilots are vital to the safety and security of their nation; however, as an occupational group, they are highly susceptible to neck pain and injury. The results of this study indicate that neck pain in fighter pilots can be predicted, at least in part, by regression models using self-reported pain data and lifestyle factors. Risk factors such as the number of flight hours, the age of the pilot, the amount of desktop hours they work, and the frequency with which they exercise their neck all have significant association with neck pain in fighter pilots. These results can be used to guide prevention strategies for airforces to consider as they move to limit the amount of injuries their pilots suffer, which in turn optimizes the effectiveness of their workforce and increases the safety of their country.

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