Prevention of flight-related neck pain in military aircrew
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Citation for published version (APA):

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Prevention of flight-related neck pain in military aircrew
Individual, work- and flight-related issues in F-16 pilots reporting neck pain

Chapter 2

Veerle De Loose, Marieke Van den Oord, Frédéric Burnotte, Damien Van Tiggelen, Veerle Stevens, Barbara Cagnie, Erik Witvrouw, Lieven Danneels

Aviation, Space, and Environmental Medicine 2008;79:779-783
Abstract

Introduction: Neck pain is a common problem in F-16 pilots. A cross-sectional survey was used to determine the self-reported one-year prevalence of neck pain and to compare individual, work-related, and flight-related characteristics in F-16 pilots with and without neck pain.

Methods: There were 90 male F-16 pilots of the Belgian Air Force and The Royal Netherlands Air Force who voluntarily completed an anonymous survey.

Results: The one-year prevalence of neck pain was 18.9%. Pilots were divided into two groups: a healthy (HG) and a neck pain group (NPG). This study could not identify individual or specific flight-related differences between these two groups. High force demands, often sitting for a long time, frequently holding the neck in a forward bent posture, and being physically tired were all physical work-related factors that were reported significantly more often in the NPG. The NPG also reported significantly more psychosocial factors, such as being mentally tired at the end of the day and being annoyed by others at the workplace.

Discussion: Since the specific flight-related factors were not significantly different between the HG and NPG, physical and psychosocial factors could have been important factors in the development or maintenance of neck pain in F-16 pilots.

Conclusion: The results of this study highlight for the first time that, in addition to flight-related issues, other aspects must be considered in analyzing neck pain. These other aspects stress the importance of a broader approach when considering neck pain, even in this population that is exposed to very high loads during flight.
Introduction

Neck pain is a well described problem among pilots flying high-performance aircrafts. The one-year prevalence of neck pain in fighter pilots is high, fluctuating between 50% and 89% [1;8]. In literature, neck pain prevalence in F-16 pilots varies between 50% and 63% [1;8;25]. These numbers are higher than in general populations, most likely due to the very dynamic environment which subjects the pilot's cervical spine to high demands [1]. In the general population, the one-year prevalence of workers with neck pain ranged from 27.1 to 47.8% [13]. Many contributing factors have already been identified in the etiology of flight-related neck pain: number of flight hours, age, neck strength, G level, repeated exposure to high $+G_z$, head position and movements, sitting posture, 30° declination of the F-16 ejection seat (ACESS II), unexpected acceleration in backseat aircrew, and use of head-mounted devices (night vision goggles (NVG), helmet, oxygen mask) [2;12;15]. However, a pilot's job also involves a number of other activities apart from flying: mission planning, briefings and debriefings, preparing materials, and administration. The nature of most of these activities is sharply in contrast with the demands of the flying assignment and requires standing and sitting postures for prolonged periods.

In the current study our aim was to determine the self-reported one-year prevalence of neck pain and to compare individual, flight- and work-related (physical and psychological) characteristics of F-16 pilots with and without neck pain. In addition, the current study sought to describe the nature of the neck pain experienced and to assess whether the pilots sought medical attention.

Methods

Subjects

The current study was a collaboration between The Belgian Air Force and The Royal Netherlands Air Force; both operate the F-16 Fighting Falcon. There were 90 male F-16 pilots who completed an anonymous survey voluntarily. The anonymity was guaranteed by using a code. A medical briefing introduced the study to the different squadrons. Later, a schedule was communicated to the pilots. After a detailed briefing and signing informed consent, the pilots completed the questionnaire. Approval for the study was obtained by the Ethical Research Committee of the Belgian Defense and of Ghent University Hospital. All pilots present participated and were included in the study. The participating percentage reached approximately 70%. Pilots were divided in two groups: a neck pain group (NPG) and a healthy group (HG). The NPG contained pilots with more than two episodes of neck pain which lasted for at least one day the past 12 months.
Questionnaire
The questionnaire was divided into three parts: a general, a work-related, and a pilot-specific part. The general part, based on the Dutch Musculoskeletal Questionnaire [18], was comprised of questions concerning personal information, health, leisure activities, neck pain, and the Neck Disability Index (NDI) [26]. Personal information consisted of questions about age, gender, height, weight, smoking habits, sleeping hours, and highest military ranking. The neck pain part of the questionnaire contained questions about the cause, the progress, and the characteristics of the neck pain.
In addition to questions about breaks, years at current job, work hours per week, and computer use, the work-related part was subdivided into physical (physically tired at the end of the day, postures, and movements) and psychosocial (mentally tired at the end of the day, job satisfaction, prospects, and job pressure) factors. The pilot-specific part contained questions about flight experience (number of flight hours, use of night vision goggles, type of airplane, flight circumstances), preventive measures (strength training, stretching, use of head rest, and prepositioning of the head), and flight-related causes of neck pain. A preface explained the aim of the survey and gave instructions on properly filling out the questionnaire, which was imported into Microsoft Office Access 2003. Neck pain was defined as pain in the head and neck region; a drawing with shading in the head, neck, and shoulder area, was shown to the subjects (Fig. 1) [9].

![Figure 1. Drawing of the head, neck, and shoulder area with a shaded head and neck region indicating 'neck pain'.](image)

Statistics
Statistical analyses were performed with SPSS 12.0 software package (SPSS Inc., Chicago, IL) for Windows. Differences between groups were calculated by cross-tabulations, a one-way-ANOVA, an independent samples t-test or a Mann-Whitney U-test (if normal data distribution was not obtained). Mean differences with 95% CI were given as descriptive statistics. In all tests, P < 0.05 was considered statistically significant.
Results

The one-year prevalence of self-reported neck pain in F-16 pilots was 18.9% (N=17). A total of 47% (N=8/17) of the NPG had complaints at the moment of completing the questionnaire and 12% (N=2/17) reported continuous pain. The pain behavior during the worst episode of pain was described as follows: “neck pain disappeared without complications after a few days”, 12% (N=2); “neck pain was not healed and occasionally recurred”, 41% (N=7); and “severity of neck pain got worse”, 41% (N=7). One pilot did not indicate the pain behavior because he experienced a much worse episode of neck pain shortly before the beginning of the study, which was still there as he completed the questionnaire. In answer to the question ‘what caused your neck pain?’, stress at the work place accounted for 12% (N=2); a sudden movements, 47% (N=8); and cause unknown, 41% (N=7). One pilot had neck pain that radiated to the shoulder combined with headache; in the remaining pilots, 18% (N=3/17) reported radiation to the shoulder, 12% (N=2/17) to the wrist, and 18% (N=3/17) had a headache. None of the pilots had ever been diagnosed with an intervertebral disk hernia. The mean score of the NDI, 3.4 (CI 0.8-6), did not reach the cut-off for mild disability (score 5) in the NPG.

Table I.: Mean flight hours reproduced for the healthy (HG) and the neck pain pilots group (NPG).

<table>
<thead>
<tr>
<th></th>
<th>HG, N=73</th>
<th>NPG, N=17</th>
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</thead>
<tbody>
<tr>
<td><strong>Mean Hours</strong></td>
<td><strong>95% CI</strong></td>
<td><strong>Mean Hours</strong></td>
</tr>
<tr>
<td>Total Flight time</td>
<td>1613</td>
<td>646-2581</td>
</tr>
<tr>
<td>Total F-16 time</td>
<td>984</td>
<td>210-1758</td>
</tr>
<tr>
<td>Weekly F-16 time</td>
<td>3.3</td>
<td>1-5.6</td>
</tr>
</tbody>
</table>

*Confidence intervals

Details about flight hours are described in Table I. The NPG reported no more flight hours than the HG. A total of 44% (N=40/90) of the pilots used NVG. Flight hours with NVG fluctuated from 1 h to 300 h. An average flight with NVG lasted 74 min (CI=51-105). The NPG reported no more flight hours with NVG than the HG. Of the NPG, 41% (N=6/17) received a flight restriction because of their neck pain; grounding varied from one week to one month (9.8 d, CI 0.6d – 19d). Pilots were asked about their preventive strategies. Results are reproduced in Table II. The reported preventive strategies of the HG were not different from the NPG.
Prevention of flight-related neck pain in military aircrew

Table II. Preventive strategies classified by healthy (HG) and neck pain pilots groups (NPG).

<table>
<thead>
<tr>
<th>Preventive measures</th>
<th>HG N=73</th>
<th>NPG N=17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength training</td>
<td>4/73 (5.6%)</td>
<td>3/17 (17.6%)</td>
</tr>
<tr>
<td>Pre-flight stretching</td>
<td>41/73 (56.9%)</td>
<td>13/17 (76.5%)</td>
</tr>
<tr>
<td>Post-flight stretching</td>
<td>5/73 (6.9%)</td>
<td>3/17 (17.6%)</td>
</tr>
<tr>
<td>Head against head rest</td>
<td>13/73 (18.1%)</td>
<td>2/17 (11.8%)</td>
</tr>
<tr>
<td>Pre-positioning</td>
<td>51/73 (70.8%)</td>
<td>14/17 (82.4%)</td>
</tr>
<tr>
<td>one movement plane</td>
<td>15/73 (20.8%)</td>
<td>4/17 (23.5%)</td>
</tr>
</tbody>
</table>

In the NPG, 77% (N=13/17) of the pilots indicated that their complaints started with flying the F-16. These pilots reported that complaints occur most likely during air combat maneuvering and basic fight maneuvering sorties without NVG and a G level exceeding 4 Gs. The maneuvers that induced the complaints were described by the NPG as the “Check-six” maneuver and turning the head towards the rear of the plane. The complaints started during the flight in 46% (N=6/13) of the NPG; and remained until the end of the flight for all pilots. In the remaining 54% of the NPG, the complaints started after the flight. The beginning of the pain varied between 10 minutes to 3 hours after the flight. In both cases, complaints disappeared after a few days.

In the NPG, 41% were younger than 30 year of age, 56% were between 30 and 39 year, and 3% were between 40 and 49 year. In the HG, 47% were younger then 30, 47% were between 30 and 39 year and 6% were between the age of 40 and 49. Mean body mass index (BMI) in the NPG was 24 (CI=21.4-27) and in the HG 24 (CI=22.5-25.7). No differences with regards to individual factors were found.

No significant differences were found in leisure and sports activities of both groups. The pilots practiced sports for 1–3 hours per week. The most popular sports were going to the gym (36%) and running (24%). No differences with regards to work experience were seen. For all subjects, the mean duration of employment was 8 year (3.3-12.7) with a mean of 41 (CI=28.3-43.7) working hours per week and a 5-day working week. All pilots in the NPG reported that their complaints started during their current job.

The NPG reported more often that their job demanded lots of force (P=0.002) and that at the end of the day they were physically tired (P=0.002). The NPG were often holding their neck in a forward bent posture (P=0.014) and were often sitting for a long time (P=0.045). The NPG reported more hours of computer work time per day (P=0.050, CI= 3.2 h/d, CI 4.6-1.8). No other physical work-related differences were found. The NPG reported significantly more that they were mentally tired at the end of the day (P=0.01) and that they were annoyed by others at their job (P=0.001). No other psychosocial work-related differences were found.

The number of pilots with neck pain seeking therapy in the previous 12 months was
relatively low. Only 24% (N=4/17) of the pilots consulted a physician and 75% of those (N=3/4) followed therapy. Physiotherapy was the most popular treatment (massage and mobilization). None of them receive active therapy, i.e., a structured rehabilitation program including specific exercises. No medication was taken.

**Discussion**

Pilots were asked if they had neck pain during the preceding 12 months. A total of 42.2% had experienced neck pain. Only 18.9% experienced more than two episodes of neck pain which lasted for at least one day during the past 12 months. This was much lower than in other studies concerning this issue [27]. In the 1980s, Bieseman et al. [8] conducted a survey in which a sample of 30 F-16 pilots participated; 50% of them reported having neck problems due to flying the F-16. In the same period, Vanderbeek et al. [25] reported minor neck injuries in 61% of operational F-16 pilots over a 3-months period. Ten years later Albano et al. [1] reported a one-year prevalence of 56.6%. In the literature, the neck pain prevalence rate in F-16 pilots varies widely; this could be attributed to the differences in the method of reporting neck pain, the differences in type of missions, newer equipment, and the adopted style of flying during the years. Yacavone et al. [27] defined cervical injuries as at least one day absence from the flight schedule, and brought the incidence of neck injuries in pilots of high performance aircrafts back to 26.8%. Literature described possible causes for higher prevalence: the F-16 pilot’s neck is in flexion in order to maintain a normal direction of gaze in relationship to the horizontal plane because of the 30° declination of the seat [19]. More specifically, an additional 15° forward flexion of the neck to the trunk is required [10]. Therefore the prevalence of neck injury seemed to be significantly higher in F-16 pilots than in F-15 pilots. Differences in type of aircraft have an effect on the occurrence of neck injury [25].

Based on the literature, only F-16 flight hours were taken into account since the other aircraft exposed pilots only to low G forces [19;20]. In the current study, the quantity of F-16 flight hours seemed to have no influence on the occurrence of neck pain. Our results are in agreement with Albano et al. [1], who reported no differences in total F-16 hours between injured and uninjured pilots concerning F-16 flight hours. Hämäläinen et al. [16] indicated that the number of flight hours was associated with experiencing acute in-flight neck pain.

In the current study, 41% (N=7) of the NPG received a restriction to fly due to their neck complaints. This restriction varied from one week to one month. Literature percentages of flight restriction were hard to compare due to differences in methodology. Newman et al. [23] reported that 7% of all F/A-18 pilots were taken off flying duties for an average period of 2 weeks. Kikukawa et al. [20] reported that due to continuing symptoms, 16
of the 129 F-15 pilots were removed from the flying mission for an extended period of time. Drew [11] reported that 48% of F-16 pilots were grounded once as a result of their neck pain. Others reported mean restriction periods of 0.8 days [1], 3 days [21] and 4 days [8].

The NPG described that the “check-six” was the most common maneuver which elicited their neck pain. This maneuver regularly demands the maximum amplitude of rotation in the pilot’s neck, often combined with lateral bending flexion and extension; this is an extreme deviation from the normal axial alignment of the neck. This is a vulnerable position for the pilot’s neck, especially when it was combined with the $+G_z$ [1;19;20].

Hämäläinen et al. [14] conducted a study in which they assessed the effect of $+G_z$ forces and head movement on the cervical erector spinae muscle strain. In the “check-six” position, the muscles’ capacity to protect the cervical spine was the lowest.

Fighter pilots were questioned about their preventive precautions for neck injury. Prepositioning the head prior to the onset of high $+G_z$, was the most reported strategy to prevent neck pain. In the current study, no significant differences were shown in the occurrence of neck pain between pilots using and those not using this strategy. However, other studies show evidence that prepositioning the head appeared to prevent minor neck injuries. Placing the head against the canopy was another preventive strategy described in the literature [1]. The questionnaire in the current study revealed that 57% of the HG and 77% of the NPG perform stretching, immediately before walking to their jet or in the cockpit before take off, almost as a routine. However, the distribution between the HG and the NPG was not different. Our results are in line with previous studies that concluded that preflight stretching may not be protective in terms of G-induced neck injury [19;23].

Traditionally, neck muscle strength training has been recommended and discussed extensively for the prevention of neck pain in this population [1;5;20].

Recent research, which counted fewer subjects than the current study, supports neck strengthening exercises based on the fact that fighter pilots with neck pain had significantly lower neck muscle strength [5]. The results of the current study, however, which are consistent with those of Newman, show no differences in the occurrence of neck pain between pilots who performed unsupervised neck strengthening exercises and those who did not [23].

No differences were found with regards to individual factors. This is in contrast with Albano et al. [1], who found that the BMI was higher in uninjured pilots. Our results are in accordance with the results of Hämäläinen et al. [16], who found no anthropometrical differences.

No differences with regards to exercise habits were reported between the NPG and the HG. The most popular sports could be categorized under whole body exercises. Some contradictions exist on the preventive effect of this kind of exercise with regards to a diminution of acute in-flight neck injuries. Albano et al. [1] did not find that whole
body exercises were associated with reduced neck injuries, and Newman et al. [23] indicated that general muscle resistance training alone was not the definitive answer for the prevention of $+G_z$-induced neck injuries. In contrast, Hämäläinen et al. [15] indicated that whole body endurance training was protective. In the current study, all pilots reported that their complaints started during their current job. In the study of Kikukawa et al. [20], 93.8% of the pilots circumscribed their neck problem as an occupational disease. The NPG in the current study reported significantly more that the following work-related factors could be related to neck pain: high force demands, often sitting for a long time, frequently holding the neck in a forward bent posture, and being physically tired at the end of the day. These factors are also described as risk factors in non-flying occupational environments [4;6;9]. Besides the physical factors, the NPG in the current study reported significantly more psychosocial factors such as being mentally tired at the end of the day and being annoyed by others at the workplace. This is in agreement with the fact that stress at the workplace was given as one of the other causes of neck pain reported by the pilots of the NPG. In other studies, concerning nonflying work environments, these factors were recognized as possible risk factors in the development of neck pain [3;7;9;24]. The pilots participating in this study reported a 40-h week, working 5 days per week. Taking the reported flight hours into account, a normal working week comprises almost 90% nonflying activities (mission planning, briefings and debriefings, preparing materials, and administration). Perhaps the contributing role of physical and psychosocial nonflying job characteristics to neck pain was underestimated in other studies. The current study illustrates that taking them into account is very important. Some of these factors such as high force demands and often holding the neck in a forward bent posture are factors fitting in the dynamic F-16 work environment. More hours of computer work time per day were recorded in the NPG. Other studies investigated the use of the keyboard during work time; they found that 4-6 hours of keyboard use per day increased the risk of neck pain [22]. Only 23.5% of the pilots who reported neck pain consulted a physician. This is rather low, but these findings were similar to other studies. Newman et al. [23] reported that 27% of the pilots had sought for medical attention during their career. A survey conducted by Drew et al. [11] showed that 43% of the F-16 pilots sought medical attention. In both studies treatment included rest, medication, and/or physiotherapy. Because repeated neck injury results in premature chronic degenerative changes in fighter pilots and because a history of neck pain is a risk factor for relapse, early reporting and treatment are necessary [1;10;17].

This study is limited by its retrospective nature; it relied on the memory of the pilots over a period of one year. There were 90 F-16 pilots who participated; only 17 of them experienced neck pain, and this could form a limitation to the conclusion drawn. The current study did not monitor the flying abilities and the different movement strategies of the pilots during flight. Pilots were informed about this study in advance by a medical
briefing; participation was voluntary, which could create a bias. However, the advance briefings and the fact that the survey was anonymous were likely to have encouraged participation. The questionnaire was protected; pilots were obligated to complete the whole questionnaire.

The one-year prevalence of neck pain in F-16 pilots was 18.9%. It appeared that in 47% of the pilots, neck pain was caused by a sudden movement and 77% reported that their complaints started due to the flight. Besides the flexed head position and the fact that the NPG reported their work to be physically demanding, no other flight-related issues were found. However, this study inquired not only about the flight-related factors of these high-performance pilots, it also took their other work-related factors into account. Being physically and mentally tired at the end of a normal working day, often sitting for a long time, and being annoyed by others at their job were work-related factors in which the healthy and the neck pain group significantly differed. Since the specific flight-related factors were not significantly different between the healthy and the neck pain group, physical and psychosocial factors could have contributed to the development of neck pain in F-16 pilots. This might signify that the flight was just the trigger needed to educe their complaints and that other physical, psychosocial, and work-related factors could have contributed to the development or maintenance of neck pain in F-16 pilots.
References