Prevention of flight-related neck pain in military aircrew
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Prevention of flight-related neck pain in military aircrew
Differences in physical workload between military helicopter pilots and rear aircrew members

Chapter 5

Marieke Van den Oord, Judith Sluiter, Monique Frings-Dresen

Submitted
Abstract

Purpose: Pilots and rear aircrew members perform different tasks when flying helicopters. The aims of the current study were to estimate the one-year prevalence of neck pain in military helicopter rear aircrew members and to compare physical workload between pilots and rear aircrew members.

Methods: A survey was completed by almost all available helicopter pilots (n=113) and rear aircrew members (n=61) of the Dutch Defence Helicopter Command. The outcome measures were self-reported neck pain and nine physical load factors that had been associated with work-related neck pain. Differences in the proportions of helicopter pilots and rear aircrew members reporting being often exposed to the particular physical load were assessed with the $\chi^2$ test.

Results: For the rear aircrew, the one-year prevalence of neck pain was 62% for any neck pain and 28% for regular or continuous neck pain. Significantly more rear aircrew members than pilots reported being often exposed to manual material handling, performing dynamic movements with their torsos, working in prolonged bent or twisted posture with their torsos or their necks, working with their arms raised and working in awkward postures. Frequent exposure to prolonged sitting and dynamic movements with the neck were equally reported by almost all the pilots and rear aircrew members.

Conclusion: Flight related neck pain is prevalent in both military helicopter pilots and rear aircrew members. The exposures to physical load factors that have been associated with neck pain differ between occupations, with more rear aircrew members subject to a variety of physical load factors. These results have implications for preventive strategies for flight-related neck pain.
Introduction

Neck pain is an occupational problem in military aviation that may interfere with flying performance and concentration [2;13;14], which makes neck pain both a health and a flight safety concern. In military aviation neck pain is a well-described problem in pilots flying fast jet aircrafts and pilots flying helicopters; two different occupations within military aviation with different job demands and different etiologies of flight-related neck pain [7;9;15;18]. The reported one-year prevalence of neck pain among F-16 pilots fluctuates from 19% to 63% [1;9] and among helicopter pilots from 29% to 57% [2;5;14], depending on the definitions, methodologies and criteria used. Recently, we found a one-year prevalence of 43% of any neck pain and 20% of regular or continuous neck pain among the military helicopter pilots of the Dutch Defence Helicopter Command (DHC) of the Royal Netherlands Air Force [18]. Depending on the type of helicopter, military helicopters are operated not only by the pilots, but also by the rear aircrew members. To better understand the etiology of flight-related neck complaints, it is important to study neck pain in both occupations.

It is generally agreed that the etiology of work-related neck pain in the general population is multi-factorial involving individual, physical and psychosocial factors and can be work-related or non-work-related [4;8]. Work-related factors that have been associated with neck pain among helicopter pilots include flying hours [18] and the use of night vision goggles (NVG) [2]. In the general working population, there is some evidence of several work-related physical risk factors for neck pain including neck postures, arm postures, duration of sitting, twisting or bending of the trunk, hand-arm vibration, awkward postures, work-place design and heavy physical work [4;8].

Helicopter pilots and rear aircrew members perform different tasks in the helicopter. The pilots work in the cockpit and fly the helicopter that, depending on the type and mission, is used to transport troops and cargo, perform search and rescue missions, and provide close combat support for ground troops. The rear aircrew members work in the cabin of the helicopter and their main tasks include troop management, material handling, hoist operation, rescue, surveillance and clearance tasks, and sensor operation. Although pilots and rear aircrew members both have to address specific factors that comes with military helicopter operations such as wearing heavy headgear while performing their tasks, their tasks differ, the work environments within the helicopter (cockpit versus cabin) differ, and consequently the physical loads differ. Because particular physical load factors have been associated with neck pain in different occupations [4;8], we were interested in the differences in exposure to these risk factors between pilots and rear aircrew members.

The aims of the current study were to estimate the self-reported one-year prevalence of neck pain in military rear aircrew of the Dutch Defence Helicopter Command (DHC) and to compare self-reported physical load between helicopter pilots and rear aircrew members.
Methods

Participants
All helicopter squadrons of the DHC were involved in this study. The squadrons are made up of six helicopter types as follows: the ICH-47D Chinook, the AS-532 U2 Cougar, the Agusta-Bell 412, the Alouette III, the Westland SH-14D Lynx helicopter and the AH-64D Apache. A total of 61 military helicopter rear aircrew members (59 men and two women) and 113 pilots (103 men and 10 women) voluntarily completed an anonymous survey. The results of this survey about the prevalence of neck pain and associated factors among the helicopter pilots have been published previously [18]. Descriptive data of the individual characteristics and flight experience of the participants are shown in Table I.

Table I. Descriptive data of individual characteristics and flight experiences of the military helicopter pilots and rear aircrew members.

<table>
<thead>
<tr>
<th></th>
<th>Pilots (n=113)</th>
<th>Rear aircrew (n=61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>183 (7)</td>
<td>182 (8)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>82 (11)</td>
<td>83 (9)</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>24.4 (2.5)</td>
<td>25.0 (2.0)</td>
</tr>
<tr>
<td>Total flying hours</td>
<td>1836 (1407)</td>
<td>1625 (1300)</td>
</tr>
<tr>
<td>Flying hours in previous year</td>
<td>164 (68)</td>
<td>196 (73)</td>
</tr>
<tr>
<td>NVG hours</td>
<td>81 (121)</td>
<td>107 (122)</td>
</tr>
</tbody>
</table>

Procedures
The helicopter squadrons were introduced to the study by an oral briefing and written information was provided to all the pilots and rear aircrew members unless they were on deployment. Each squadron was then visited on three to four consecutive days, depending on the presence of the pilots (November 2006-March 2008). Only crew members who were on deployment, or on sick- or holiday leave were not reached and were excluded from recruitment. Almost all the pilots and rear aircrew members present on these days participated (96% response rate) and gave their written informed consent. Ethical approval for the study was waived because the questionnaires were anonymous and contained no material subject to privacy constraints.

The questionnaire was based on the standardized “Dutch Musculoskeletal Questionnaire” (DMQ) [12] and contained additional questions about flight-related issues, including flying hours and experience. Participants reported to a member of the research team who was housed in or near the squadron building. The researcher gave
instructions to each participant about the process of filling out the questionnaire. The questionnaires were completed electronically, using Microsoft Office Access 2003 and typically time needed to complete the questionnaire was 20 minutes. Selected items from this questionnaire were used to answer the specific research questions of the current study.

**Work-related physical load**

The work-related physical load part of the questionnaire consisted of twenty yes/no questions. Twelve questions were considered to be relevant for this study, based on earlier research that identified specific physical risk factors for work-related neck pain [4;8]. These questions were as follows:

During your job, do you often:

1. lift/pull/push loads of more than 5 kg
2. lift/pull/push loads of more than 20 kg
3. bend or twist your torso
4. bend or twist your neck
5. make repetitive movements with your torso
6. make repetitive movements with your neck
7. work in a prolonged bent or twisted posture with your torso
8. work in a prolonged bent or twisted posture with your neck
9. work with your arms raised
10. work in awkward postures
11. work in the same position/posture
12. sit for prolonged durations

**Outcome measures and analyses**

The outcome measure for the first research question of the study was self-reported neck pain. Neck pain was defined in the questionnaire as any pain, including aches and discomfort in the previous 12 months; in addition, a diagram was used to illustrate and define the specific body region. There were four possible choices: never, occasional, regular or continuous pain.

To answer the second research question of the study, the questions assessing physical loads of the same order were combined into one outcome measure in the analyses. Participants answering YES on one of these questions were considered in the YES-group for this outcome measure, resulting in the following nine outcome measures: often exposure to material handling (question 1 and 2), dynamic movements with the torso (question 3 and 5), dynamic movements with the neck (question 4 and 6), prolonged bent or twisted posture with the torso (question 7), prolonged bent or twisted posture with the neck (question 8), raised arms (question 9), awkward postures (question 10), prolonged the same position/posture (question 11) and prolonged sitting (question 12).
Statistical analyses were performed with SPSS 18.0. Differences in the proportions of helicopter pilots and rear aircrew reporting being exposed often to the particular physical load were assessed with the $\chi^2$ test. When the assumption of a minimal expected number of 5 in each of the four cells was violated, Fisher’s exact test was used to obtain the p-value. A p-value of < 0.01 was considered to be statistically significant.

**Results**

The one-year prevalence of self-reported neck pain of the rear aircrew was 62% (n=38/61) for any neck pain, and 28% (n=17/61) for regular or continuous neck pain. All but one of the rear aircrew members reporting regular or continuous neck pain attributed their neck pain to flying, and 77% indicated that their complaints started during flights.

The self-reported physical load of the pilots and rear aircrew are shown in Table II. Significantly more rear aircrew members than pilots reported often being exposed to manual material handling ($\chi^2 = 80.3$, 1 d.f., p<0.000), performing dynamic movements with their torsos during work ($\chi^2 = 28.7$, 1 d.f., p<0.000), working in a prolonged bent or twisted posture with their torsos ($\chi^2 = 32.1$, 1 d.f., p<0.000) and their necks ($\chi^2 = 19.3$, 1 d.f., p<0.000), working with their arms raised ($\chi^2 = 11.5$, 1 d.f., p= 0.001) and working in awkward postures ($\chi^2 = 57.1$, 1 d.f., p<0.000). Significantly more pilots than rear aircrew members reported often being exposed to prolonged work in the same position/posture during their job ($\chi^2 = 10.9$, 1 d.f., p= 0.001). Almost all pilots (97%) and rear aircrew (100%) reported often making dynamic movements with their necks during their job. Almost all pilots (96%) reported being exposed to prolonged sitting, but this proportion was not significantly higher than the proportion rear aircrew members (85%) reporting being exposed to prolonged sitting (p=0.037).

**Table II.** Percentage of the pilots and rear aircrew members often exposed to the different aspects of physical workload.

<table>
<thead>
<tr>
<th></th>
<th>Pilots (n=113)</th>
<th>Rear aircrew (n=61)</th>
</tr>
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<tbody>
<tr>
<td>Manual material handling</td>
<td>24%</td>
<td>95% *</td>
</tr>
<tr>
<td>Dynamic movements with torso</td>
<td>61%</td>
<td>98% *</td>
</tr>
<tr>
<td>Dynamic movements with neck</td>
<td>97%</td>
<td>100%</td>
</tr>
<tr>
<td>Prolonged bent or twisted posture with torso</td>
<td>43%</td>
<td>87% *</td>
</tr>
<tr>
<td>Prolonged bent or twisted posture with neck</td>
<td>56%</td>
<td>89% *</td>
</tr>
<tr>
<td>Raised arms</td>
<td>15%</td>
<td>38% *</td>
</tr>
<tr>
<td>Awkward postures</td>
<td>34%</td>
<td>93% *</td>
</tr>
<tr>
<td>Prolong same position/posture</td>
<td>91% *</td>
<td>72%</td>
</tr>
<tr>
<td>Prolonged sitting</td>
<td>96%</td>
<td>85%</td>
</tr>
</tbody>
</table>

* Significantly higher proportion compared to the other occupation, p<0.01
Differences in physical workload between military helicopter pilots and rear aircrew members

**Discussion**

**Main results and comparison with the literature**

Based on the levels of the prevalence rates found (>25%), and the statements by almost all the aircrew members indicating that neck pain was flight-related, the results of the current study suggest that for the rear aircrew members, neck pain is a work-related problem. Considering the second aim of this study, the results suggest that the exposure of the pilots and rear aircrew members to physical load factors that have been associated with neck pain differ between occupations. The rear aircrew members are more often exposed to manual material handling, making dynamic movements with their torsos, working in prolonged bent or twisted postures with their torsos and necks and working with raised arms compared to the pilots, whereas the helicopter pilots more often experience prolonged body positions/postures compared to the rear aircrew. Often exposure to prolonged sitting and dynamic movements with the neck were reported equally by almost all the pilots and rear aircrew members.

The overall one-year prevalence of neck pain among the military helicopter rear aircrew members was 62% for any neck pain and 28% for regular and continuous neck pain. These year prevalence rates tend to be higher compared to those (43% of any and 20% of regular and continuous neck pain) among the helicopter pilots of the Dutch Defence Helicopter Command (DHC) [18]. Higher prevalence rates of neck pain in rear aircrew compared to pilots were reported in British military helicopter crew, for whom the career prevalence of flight-related neck pain was 57% for the pilots and 71% for the rear aircrew [11]. Non-flying Dutch workers reported a one-year prevalence of 55% for any neck pain and 22% for regular and continuous neck pain [17], which are approximately the same as those for the rear aircrew of the DHC. However, the rear aircrew members of the DHC have to meet medical and physical standards when they enter the defence organization and are medically and physically checked annually; thus rear aircrew members are assumed to be in a better physical condition compared to the non-flying working population. These results indicate a higher risk for neck pain among the rear aircrew than the non-flying working population.

The second aim of this study was to compare the self-reported exposure to physical load factors that have been associated with work related neck pain between the helicopter pilots and rear aircrew members. Here, a number of results are noted. The vast majority of the rear aircrew members report being often exposed to almost all of these physical load factors. Within the pilot group, a convincing majority reported being often exposed only to prolonged the same posture, to prolonged sitting and to performing dynamic movements with the neck. This indicates that the rear aircrew is exposed to a greater variety of physical loads. Because their tasks are more varied compared to the tasks of the pilots, this is not surprising.

A second finding is that almost all the pilots and all rear aircrew members report being often exposed to dynamic movements with their neck. In addition, a small majority of
the helicopter pilots and a vast majority of the rear aircrew members reported often exposure to prolonged bent or twisted postures of their neck. Recently, Forde et al. [10] found that the percentage of time spent in a non-neutral neck position was 48% during day-time flights and 87% during night-time flight for pilots. We could not find any studies that investigated the neck postures of rear aircrew. Several studies have shown that time spent in a non-neutral position is positively associated with neck pain [3;4]. As Forde et al. [10] suggested, it would be interesting to measure the cumulative neck load that pilots and rear aircrew members are exposed to, because both helicopter pilots and rear aircrew members wear heavy headgear, which increases moment loading on the neck compared to a non-neutral posture without headgear. Cumulative loading addresses loading force a joint experiences over a particular period of time and is influenced by a combination of posture, repetition, duration and force; furthermore cumulative loading has been found to be a risk factor in pain associated with the lower spine [6], but has not been investigated in relation to neck pain.

Implications for prevention
The results of the current study show that rear aircrew and pilots are two occupations flying in the same helicopter but exposed to a different variety of physical load factors. In both professions work-related neck pain is prevalent. Interventions aiming to prevent this flight-related neck pain may therefore be job specific or could focus on the similarities of the two occupations, resulting in an intervention that benefits both occupations.

Is it possible to reduce the exposure to the flight related physical workload for both the rear aircrew members and the pilots? At the organizational level, reduction in exposure might be accomplished by reducing flying hours; however, considering the operational demands and the maintenance of the flight skills of the crew, this reduction is not feasible.

The results of the current study reveal that the pilots and rear aircrew are both often exposed to dynamic movements with their neck. At the technical level, an intervention that might be profitable for both the rear aircrew and pilots, could involve modification to their headgear. Pilots and rear aircrew wear heavy head worn equipment as a flight helmet and mounted devices such as NVG’s, head-up displays and counterweights. Recently we showed that modifications of this equipments realized by optimizing the helmet fit, resulted in less neck load and neck pain experienced by the pilots and rear aircrew during night flights [19]. In a qualitative study [20], we identified three factors that directly related to the experienced neck load by the aircrew during flight: the type of flight operations, the weight of the headgear and the weight distribution of the headgear. Because of the operational mission of the DHC, changes in the type of flight operations are not feasible. Thuresson [16] revealed that both neck postures and different configurations of headgear caused measurable changes in muscle activity and induced load. These results and the fact that both the pilots and rear aircrew members
in the current study reported being often exposed to dynamic neck movements, indicate that additional modifications to the headgear related to its weight and weight distribution, could impact the cumulative load as noted earlier in this discussion for both the rear aircrew members and pilots.

Another intervention both the rear aircrew members and pilots could profit from is to provide information about the work-related physical load factors and physically demanding work postures and their relation to symptoms. This information can improve their awareness, lead to behavioral changes, and might result in less demanding postures and activities. The information provided to the crew should be based on the physical loads they are exposed to and therefore should be profession-specific for both the rear aircrew members and pilots. Nevertheless, the evidence for the effectiveness of these types of educational interventions for neck pain is unknown.

**Conclusion**

Neck pain is a prevalent flight related problem in military helicopter crew. We observed differences in the self-reported exposures to physical load between rear aircrew and pilots; more rear aircrew members than pilots were exposed to manual material handling, dynamic movements with their torsos, prolonged bent or twisted posture with their necks and torsos, work with raised arms and awkward postures. More pilots than rear aircrew members reported being exposed to prolonged the same position/posture, while almost all the pilots and rear aircrew members were exposed to dynamic movements with their necks and prolonged sitting. These results provide information about the physical workload the pilots and rear aircrew are exposed to that have been associated with neck pain in other occupations and have implications for preventive strategies for flight-related neck pain.
References


