Prevention of flight-related neck pain in military aircrew

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Neck pain in military helicopter pilots: Prevalence and associated factors

Chapter 4
Abstract

Our aim is to estimate the self-reported one-year prevalence of neck pain in military helicopter pilots and to compare work-related, individual and health-related factors in the pilots with (neck pain group) and without (reference group) regular or continuous neck pain. A questionnaire was completed by 75% (n = 113) of all military helicopter pilots of the Royal Netherlands Air Force and Navy.

The reported year-prevalence of any neck pain was 43%, and 20% for regular or continuous neck pain. Besides some significant differences in individual and health-related factors (also often reported in the general population), flying hours were significantly higher in pilots with neck pain compared to their colleagues without neck pain.

The findings in this study suggest that neck pain in military helicopter pilots is a significant occupational problem and may be a consequence of longer exposure to flying.
Introduction

Neck pain in military pilots has been a subject of research for many years. The focus, however, has primarily been on neck pain among pilots flying high performance jet aircraft [13;17;22;27]. In the past decade, neck pain among helicopter pilots has been discussed in the literature [4;5;21], with the reported prevalences ranging from 29% to 57% [3;6;24].

In the general population, neck pain is thought to be multifactorial, suggesting that there are a number of risk factors contributing to its development. Health-related factors such as previous pain episodes, pain in body regions related to the neck, and physical and mental fatigue at the end of the working day have been reported as risk factors in the non-military population [7;10;19]. Other factors that have been associated with neck pain in the general population include individual factors such as age and gender, although these results have not been consistent [9;10;23]. Furthermore, work-related factors such as computer use and insufficient job satisfaction have been reported as potential risk factors [7;11].

The role of military pilot has specific job demands, and among these, several contributing factors have already been identified in the etiology of flight-related neck pain in pilots of jet aircraft [8]. However, flying a jet aircraft is not the same as flying a helicopter. Jet pilots are exposed more often to repeated high \( +G_z \) forces compared to helicopter pilots, and this exposure, together with extreme head positions and movements, has been identified as the primary risk factor for neck pain in these pilots [14;17]. When flying a helicopter, it is the ergonomic setting (with poor neck and body positions), whole-body vibration and heavy equipment worn on the head that have been suggested as risk factors for neck pain among helicopter pilots [25]. Research into these factors in neck pain in this population is limited, but is needed to enable preventative measures.

Our aim in this research is to estimate the self-reported one-year prevalence of neck pain in military helicopter pilots in the Royal Netherlands Air Force and Navy, and to compare work-related, individual and health-related factors in pilots with and without regular or continuous neck pain.

Neck pain in military helicopter pilots: Prevalence and associated factors
Methods

Subjects and Procedures
A total of 113 helicopter pilots, 103 males and 10 females, of The Royal Netherlands Air Force (RNLAF) and The Royal Netherlands Navy (RNLN), voluntarily completed an anonymous survey. Anonymity was assured with the use of codes to identify survey-takers. A verbal briefing introduced the study to all helicopter squadrons of the RNLAF and the RNLN, and the pilots received additional written information. Each squadron was then visited by the research team on three to four consecutive days, depending on the presence of the pilots (November 2006 – March 2008). The first author (M.VdO) was present on all visits. Only pilots who were on deployment, sick- or holiday leave were not reached and were thus excluded from recruitment. Almost all pilots present participated and all were on active flying duty (96% response rate). The 113 participants represented approximately 75% of all Dutch military helicopter pilots on active flying duty at the time of the survey. All pilots 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), which was found to be valid [18]. The questionnaire was extended to include questions about flight-related issues and retrospective information on flight-related exposures. Pilots were asked to report to a member of the research team, who was housed in or near the squadron building. The researcher gave instructions to each pilot about the process of filling out the questionnaire, and the questionnaires were completed electronically, using Microsoft Office Access 2003. Typical time needed to complete the questionnaire was 20 minutes.

Table I shows the age-distribution and flight experience details for the sample. The mean (SD) body height, body weight and body mass index of the pilots were 183 (7) cm, 82 (11) kg and 24.4 (2.5) kg/m², respectively. At the time of the survey, 60 pilots flew transport helicopters for the RNLAF: (the ICH-47D Chinook (n = 20), the AS-532 U2 Cougar (n = 26), the Agusta-Bell 412 (n = 8), or the Alouette III (n = 6)). An attack helicopter, the (AH-64(D) Apache, was flown by 33 RNLAF pilots, and the Westland SH-14D Lynx helicopter, the RNLN transport helicopter, was flown by 20 pilots.
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Table I. Mean values (SD) and median values (interquartiles) for years as military pilot, total flying hours, flying hours previous year and total number of NVG hours.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Years military helicopter pilot</th>
<th>Total flying hours</th>
<th>Flying hours previous year</th>
<th>Total NVG hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30</td>
<td>41</td>
<td>6 (3)</td>
<td>867 (675)</td>
<td>168 (56)</td>
<td>52 (57)</td>
</tr>
<tr>
<td>30-40</td>
<td>51</td>
<td>10 (3)</td>
<td>1754 (919)</td>
<td>176 (63)</td>
<td>79 (69)</td>
</tr>
<tr>
<td>&gt;40</td>
<td>21</td>
<td>21 (5)</td>
<td>3927 (1235)</td>
<td>130 (89)</td>
<td>142 (240)</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>11 (6)</td>
<td>1836 (1407)</td>
<td>164 (68)</td>
<td>81 (121)</td>
</tr>
</tbody>
</table>

Median (IQR) 9 (6 – 14) 1300 (888 – 2581) 180 (120 – 200) 50 (0-100)

Values are given per age-category and for the whole sample (103 male pilots and 10 female pilots). NVG, night vision goggles.

Neck Pain

The outcome measure was self-reported neck pain in the previous year. Neck pain was defined as any pain, including aches and discomfort, and a diagram was used to illustrate and define specific body regions. On the basis of their responses to the pain question (response choices: never, occasional, regular or continuous), the pilots were further divided into the neck pain group (pilots reporting regular or continuous neck pain in the previous year) and the reference group (pilots reporting no or occasional neck pain in the previous year).

Work-related, Individual and Health-related Factors

Independent variables, below, in the analyses were selected based on our hypotheses as well as previous research.

- Individual factors: age (three categories were used in the analyses: <30 yr, 30-40 yr, >40 yr), gender, body height and body weight from which the body mass index (weight (kg) / height (m²)) was calculated.
- Health-related factors: reported physical and mental fatigue at the end of the working day (dichotomous: yes/no), doing specific neck strength exercises (yes/no), and co-morbidities that included history of neck pain in the preceding 12 months (yes/no) and pain in body regions related to the neck (shoulders, thoracic spine, and low back) in the previous year (no or occasional pain/regular or continuous pain).
- Work-related factors: type of helicopter, total flying hours, hours flown in the previous year, total hours flown with night vision goggles (NVG), and perceived relationship of neck complaints to flying. Pilots were asked to look up their specific flight hours in their flight log before they filled out the questionnaire. Pilots who never flew with NVG (n=29) were included in that analysis concerning NVG-hours with 0
hours. Other work-related factors were: duration of computer time per workday and general job -satisfaction (responses: good / reasonable, fair / mediocre, poor). For “type of helicopter,” three helicopter aircraft categories were used: 1) the Westland SH-14D Lynx helicopter, a transport helicopter flown by pilots of the RNLN; 2) the ICH-47D Chinook, the AS-532 U2 Cougar, the Agusta-Bell 412 or the Alouette III, all transport helicopters flown by pilots of the RNLAF; 3) The AH-64 (D) Apache, an attack helicopter flown by pilots of the RNLAF.

Analyses and Statistics
Statistical analyses were performed with SPSS 15.0 (Statistical Package of Social Science). The mean and standard deviation were used to describe normally distributed continuous data, otherwise the median and interquartiles were also stated to describe the 50th, and 25th to 75th percentiles. Differences between the neck pain group and the reference group were assessed with the chi-squared test for categorical data (type of helicopter, job -satisfaction, age, gender, specific neck strength exercises, physical and mental fatigue at the end of the working day, history of neck pain, and pain in body regions related to the neck). For numerical data (total flying hours, flying-hours previous year, total NVG hours, body height and body weight), independent samples t-tests were used or Mann-Whitney U tests when data distribution was not normal. A p value of \(< 0.05\) was considered statistically significant.

Results
The overall year-prevalence of any self-reported neck pain was 43 % (CI: 38%-48%) (n=49/113). Twenty percent (CI: 16%-24%) (n=22 / 113) of the pilots reported regular or continuous neck pain; this subset made up the neck pain group in this work. The neck pain group reported significantly more total flying hours (p=0.005), as well as more flying hours in the previous year (p=0.02), than the reference group. No significant differences in total NVG- hours were found between the two groups, although almost half of the neck pain pilots (9/22) reported that their neck pain was associated with NVG -use.

Table II shows the total flying hours, flying hours in the previous year and total hours flown with NVG by group. Over 90% (20/22) of the neck pain group attributed their pain to flying, and of these 74% (14/20) indicated that their complaints started during flight. Considering the type of helicopter flown, 15% (3/20) of the pilots flying the Lynx helicopter, 28% (17/60) of the pilots flying one of the RNLAF transport helicopters and 6% (2/33) of the pilots flying the Apache helicopters reported regular or continuous neck pain in the prior 12 months. These differences were found to be significant ($\chi^2 = 7.0$, 2 df , p = 0.03). Among work-related factors other than flight-specific issues, no
significant differences were found between the groups in job satisfaction or duration of daily computer work. Across all pilots, the mean (SD) hours of computer work time per day was 3.1 (1.5) hours.

**Table II.** Total flying hours, flying hours previous year and total number of NVG-hours for the neck pain group and the reference group (male and female pilots together).

<table>
<thead>
<tr>
<th></th>
<th>Total flying hours</th>
<th>Flying hours previous year</th>
<th>Total NVG hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neck Pain Group</strong></td>
<td>Mean (SD) 2644 (1596)</td>
<td>197 (77)</td>
<td>140 (227)</td>
</tr>
<tr>
<td>(n = 22)</td>
<td>Median (IQR) 2635 (1063-3695)*</td>
<td>182 (178–222) †</td>
<td>60 (15-164)</td>
</tr>
<tr>
<td><strong>Reference Group</strong></td>
<td>Mean (SD) 1641 (1293)</td>
<td>156 (64)</td>
<td>67 (72)</td>
</tr>
<tr>
<td>(n = 91)</td>
<td>Median (IQR) 1140 (825-2000)</td>
<td>154 (120–200)</td>
<td>50 (0-100)</td>
</tr>
</tbody>
</table>

* Significant difference Neck Pain group compared to Reference group, p=0.005,
† Significant difference Neck Pain group compared to Reference group, p = 0.02

The neck pain group reported a significantly higher incidence of physical fatigue at the end of the working day ($\chi^2 = 5.7, 1$ df, $p = 0.02$). Pilots were asked whether they performed specific strength exercises for the neck area. Thirty pilots (27%) actually performed such exercises, but they were proportionally not different represented in the neck pain group and reference group. When asked about any previous episodes of neck pain experienced more than 12 months ago, the neck pain group reported a significantly higher frequency of previous history of neck pain ($\chi^2 = 28.3, 1$df, $p<0.001$) compared to that in the reference group. The one-year prevalence of regular or continuous shoulder, thoracic or low back pain was 7% (n=8/113), 12% (n=14/113) and 26% (n=29/113), respectively. These data and the number of pilots with regular or continuous neck pain within these pain groups are shown in **Table III.** The pilots in the neck pain group reported higher prevalence of regular and continuous pain in shoulders ($\chi^2 = 5.5, 1$ df, $p = 0.04$) and upper back ($\chi^2 = 14.5, 1$ df, $p < 0.001$), but the prevalence of regular and continuous pain in the lower back was not different across groups.

No significant differences were found regarding body height, weight and BMI between groups. A significant trend was seen between the presence of regular or continuous neck pain and age ($\chi^2 = 6.7, 1$df, $p = 0.009$). Female pilots reported significantly higher prevalence of regular or continuous neck pain than did their male colleagues ($\chi^2 = 6.5, 1$ df, $p = 0.02$).
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Table III. Number of pilots with regular and continuous shoulder, thoracic and low back pain and the number of cases with regular and continuous neck pain within these groups.

<table>
<thead>
<tr>
<th></th>
<th>Number of pilots</th>
<th>Cases of Neck Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder pain</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Thoracic pain</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Low back pain</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>Total (n)</td>
<td>113</td>
<td>22</td>
</tr>
</tbody>
</table>

Discussion

The findings in this study suggest that neck pain in military helicopter pilots is a significant occupational problem, and may be a consequence of longer exposure to flying; additional factors possibly relating to pain are older age, female gender, fatigue at the end of the working day, previous neck pain episodes and pain in shoulder and upper back.

While interpreting the results of this study, some consideration should be taken into account. The number of pilots in the neck pain group was too small to construct a logistic regression model, which would have allowed us to assess all risk factors related to regular and continuous neck pain, and mitigate the effects of confounding variables. The number of participants was limited by the size of the total population of military helicopter pilots in the Netherlands. The present sample covered all helicopter squadrons of the RNLAF and RNLN and only pilots on military deployment, holiday or sick leave were not included in the recruitment. Since almost all available helicopter pilots participated, which covered 75% of all military helicopter pilots on active flying duty, the present sample was considered representative for the population of the RNLAF and RNLN helicopter pilots.

Further, these self-reports of neck pain relied on the memory of the pilots over a period of one year. In addition, pilots are known to be reluctant to report physical complaints because of fear of restriction of flying. By having an independent research team administer the questionnaire at the pilot’s workplace instead of during the pilot’s periodic medical exams at the medical center, and by guaranteeing anonymity, we believe we have lessened pilots’ reluctance.

The overall one-year prevalence of any neck pain in military helicopter pilots was 43% (CI: 38%-48%), and 20% (CI: 16%-24%) for regular and continuous neck pain. Only a few previous studies have reported the prevalence of neck pain in helicopter pilots. The prevalence found in this study was lower than that of a previous Swedish study, where the 3-month prevalence of neck pain in helicopter pilots was found to be 57%, while 32% reported regular neck pain [3]. Two studies that focused on back pain among helicopter pilots, but also asked about neck pain in their survey, found a 12-month
prevalence of neck pain of 29% [24] and 48% [6]. Neither of those two studies made further distinctions in occasional versus regular or continuous neck pain. Prevalence of musculoskeletal pain often fluctuates from study to study because of different methodologies and criteria, which makes making an adequate comparison difficult. In a recent national Dutch survey on working conditions among approximately 22,000 Dutch workers in various jobs, definitions and outcome measures similar to ours were used [26]. The overall 12-month prevalence of any neck pain in that population was 55%, and 22% reported regular or continuous neck pain. The latter prevalence is similar to our findings, suggesting that helicopter pilots are at no greater risk for developing neck pain than the non-flying working population. However, the helicopter pilots in the current study were a selected population. Pilot candidates of the RNLAF and RNLN have to meet medical and physical standards, and our pilots are therefore assumed to be a population in better physical condition than the average worker. From this perspective, a lower prevalence of musculoskeletal pain would be expected, and these similar prevalence figures could thus indicate a relatively higher risk for neck pain in helicopter pilots.

That our sample came from a healthier than typical population was further confirmed by the relatively low prevalence of regular and continuous pain in the shoulder, upper back and lower back regions in our group. The neck pain group more often reported a history of neck pain more than 12 months ago compared to the reference group. Such previous pain episodes have been found to be an important risk factor in several neck pain surveys among the general population as well as in helicopter pilots [3;7;10;16]. Specific strength training for the neck area has been suggested to prevent neck pain in military jet and helicopter pilots [1;2;4]. In the current sample, only 27% of the helicopter pilots actually performed such exercises, but the percentages of these pilots were not different between the groups. In a systematic review, moderate evidence of benefit for neck pain patients was found when the stretching and strengthening exercises focused on the neck area [20]. However, evidence for the preventive effect of such exercises in a healthy population is scarce and should be an issue of interest in future studies.

When considering the individual factors, female pilots reported significantly more frequent, regular and continuous neck pain than their male colleagues did. The female pilots did not differ in age, flight-hours or NVG-hours compared to their male colleagues. In the general population, contrasting results have been published, although the majority of these studies indeed showed higher prevalence of neck pain for women than for men [19]. Females differ in neck anthropometry, with significantly smaller anthropometric parameters of the neck compared to size-matched (standing-height and neck length) males. Furthermore, females have 33% more head mass per unit neck muscle area than in size-matched males [28]. Taking into account the mass of the helmet and additional head-mounted displays that military pilots commonly use and the percentage of head mass per unit neck muscle area become even higher for females.
compared to males. This factor may play a significant role in the higher prevalence of neck pain in female helicopter pilots compared to their male colleagues.

Total flying hours and the flying hours in the previous year were significantly higher in the neck pain group compared to the reference group. In the Swedish study of military helicopter pilots, results of a multivariate analysis suggested that neither total flying hours nor flying hours in the previous year were found to be risk indicators for neck pain in the past 3 months [3]. Although that study did make a distinction between occasional and frequent neck pain, analyses were made with both groups combined. The difference between this occasional pain group and the pilots reporting no neck complaints might not have been distinctive enough to show an association. Furthermore, it was not clear in their study how many pilots attributed their neck pain to flying. In the current study, we chose to do our analyses with the outcome measure of “regular or continuous neck pain”. This allowed us to focus on the more serious cases of neck pain with respect to frequency and duration. In our study, only 22% of the pilots who reported occasional neck pain attributed their neck pain to flying, while 90% of the pilots who reported regular or continuous neck pain felt their neck pain was a consequence of flying. The association of flying hours with neck pain is in agreement with the study by Thomae et al. [24] on back pain in Australian helicopter pilots, in which prevalence of neck pain was a secondary outcome. Although no association was found between back pain and total flying hours, pilots who complained of neck pain in the study had flown significantly more hours than pilots who did not have pain. Our findings also indicate that neck pain in helicopter pilots may be a consequence of long-term exposure to flying. We believe that the significantly higher number of reported flying hours reported in the previous year by the pilots in the neck pain group compared to the reference group may be a short-term effect, thus further confirming a long-term effect of the total flying hours.

It may be argued that these findings are the consequence of confounding by age, as a significant trend was observed between those reporting regular and continuous neck pain and older age in our data. However, total flying hours logically increased with total career-length and thus with older age (Table I). This fact, along with equivocal reported results about the effect of age on neck pain in the literature, further suggests that it is total flying hours that are associated with flight-related neck pain.

In the Swedish study [3], the use of NVG was reported to be the only flight-related factor indicating an increased risk for neck pain, although this finding was not significant. In a NATO Research and Technology Organization (RTO) report, Greeves and Wickes [15] reported that an increased total number of NVG flying hours was associated with an increased probability of having suffered flight-related neck pain. Helicopter pilots in their study who had flown over 700 hours using NVG had more than an 80% likelihood of developing neck pain, compared to less than 53% for those pilots with fewer than 200 hours flown with NVG. In the current study, total hours flown with NVG was not significantly associated with the prevalence of neck pain. On average, the
pilots in our study had flown 81 hours with NVG. This relatively low number, however, may be insufficient to demonstrate an association between NVG flying hours and the prevalence of neck pain. Hostile missions are increasingly executed in the darkness, and nighttime training operations are therefore becoming more important in the RNLAF and RNLN. The use of NVG will increase, and we may see changes in pain outcomes due to greater use of NVG equipment.

The ergonomic situation when flying a helicopter may play a role in developing neck complaints. Cockpit design, seats, vibration frequencies and helmet-use are factors that differ among helicopter types. Since it is common for pilots of the RNLAF to have flown more than one type of transport helicopter, analyses between single types of helicopter would not have been appropriate. Therefore, the analyses were made among three categories: pilots flying the Lynx helicopter, the RNLAF transport helicopters and the Apache attack helicopter. This classification allowed discrimination among the helmet types used, as well: the alpha 200 (Helmet Integrated Systems LTD), the HGU-56/P (GENTEX) and the Integrated Helmet Unit (Honeywell Minneapolis), respectively. The prevalence of regular or continuous neck pain significantly differed among these groups. However, further analyses revealed that these groups also differed in total flying hours and conclusions should therefore be made with caution (mean (SD) for total flying hours for pilots flying the Lynx helicopter; pilots flying the RNLAF transport helicopters; and pilots flying the Apache were: 1620 (1219), 2203 (1590) and 1298 (896) respectively). However, ergonomic situations, including helmet type and types of helmet-mounted devices, may differ among types of helicopters; these differences should be taken into account when preventive measures are developed.

In addition to flying, there are numerous other activities in a pilot’s job. Several studies have demonstrated the associations between duration of computer work and general job dissatisfaction with neck pain [7;12]. Neither of these factors was found to be associated with neck pain among our sample. This lack of association further suggests a link between flight-specific issues and neck pain in helicopter pilots.

Conclusions and recommendations
The one-year prevalence of any neck pain was 43%, and 20% for regular or continuous neck pain, in Dutch military helicopter pilots; this figure is similar to that for the Dutch non-flying working population. However, because military helicopter pilots are believed to be a healthier-than-average population, this prevalence may indicate a higher risk for neck pain in military helicopter pilots and must be taken seriously. Furthermore, in addition to significant differences in individual and health-related factors (also often reported in the general population), flying hours were significantly higher in pilots with neck pain compared to their colleagues without neck pain. This finding indicates that neck pain in helicopter pilots may be a consequence of long-term exposure to flying. Since reducing flying hours will result in poorly trained helicopter pilots, and further operational demands make reducing flying hours virtually impossible, studies should
be undertaken to determine if ergonomic improvements in cockpit design, seats and helmets would mitigate long-term neck pain incidence. Furthermore, encouragement of specific neck exercises may be a useful prevention strategy, based on previous research in which they reduced complaints in neck pain patients; more research is necessary to demonstrate a preventive effect in this population.
References


