Back Pain in Australian Military Helicopter Pilots: A Preliminary Study

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Overseas studies indicate that back pain can have important implications for operational readiness and flying performance. In a review of groundings and flying restrictions among military personnel in Canada, low back pain was the second most common cause for operational flying restriction (22), while Shanahan and colleagues report that back pain may not only distract a pilot from his/her duties but may also cause missions to be either hurried or refused (19). The impact of low back pain on pilot performance in Australia, however, has not been previously examined.

There are also no published data on either the prevalence of, or risk factors for, back pain among Australian military helicopter pilots. The aims of this study, therefore, were to determine the prevalence of back pain among helicopter pilots serving in the Australian Defence Force (ADF), identify possible risk factors for that pain, and explore some of the immediate effects of back pain on flying performance.

METHODS

Study Subjects

The source population for the study consisted of helicopter pilots attached to the Royal Australian Navy (RAN) and Australian Regular Army (ARA) rotary wing squadrons in the three eastern states of Australia (New South Wales, Queensland, and the Australian Capital Territory). These comprise the majority of helicopter squadrons in the country. Six RAN and ARA bases, comprising 11 helicopter squadrons took part in the study.
Self-completion questionnaires were distributed to all pilots present in Australia and contactable by mail at the time of the survey.

Study Instruments and Data Collection

The study was approved by both the University of Newcastle and the Australian Defence Force medical ethics committees. The questionnaire consisted of 69 questions and took approximately 20 min to complete. Pilots provided details concerning basic demographic data (e.g., age, education), history of previous back or neck injury, and information concerning potential risk factors for back pain identified from previous literature (e.g., smoking, obesity, heavy vehicle driving, family history, previous back injury). In addition, specific questions were asked about the presence and nature of any back pain or discomfort experienced either during or after flying, its variation with aircraft type and posture, and its effect on flying performance.

Questionnaires were distributed by one of us (M.T.) following a special briefing session in which the pilots were told about the aims and objectives of the project. Those pilots who did not attend received the questionnaire together with an explanatory letter by mail. Reminders were sent on a fortnightly basis over a 3-mo period. Participants were also asked to provide details of the number of hours flown in both rotary and fixed wing aircraft directly from their logbooks. Pilots who failed to respond after 3 mo were asked to complete an abbreviated questionnaire which sought information on their basic demographic details, reasons for non-response, and presence or absence of back pain.

Analyses were undertaken using the STATA Release 4 and BMDP statistical software (6,8). The mean and standard deviation were used to describe normally distributed continuous data, otherwise the median and interquartile range (IQR) were used to describe the 50th and 25th to 75th percentiles, respectively. Because of skewed distribution of the data, the Mann-Whitney U test was used to assess the associations between flying hours and back pain, while chi-square ($\chi^2$) and Fisher's exact tests were used when appropriate to examine associations between categorical data. Multiple logistic regression (MLR) was used to determine the most significant predictors of back pain after controlling for potential confounders. The goodness of fit of the model was assessed using the Hosmer-Lemeshow $\chi^2$ statistic. Denominators may vary between questions because of missing data.

RESULTS

Characteristics of the Study Sample

Of 200 eligible pilots, 131 (66%) returned the questionnaire. All study participants were male with a median age of 28 yr (IQR 25-32 yr). More than half the sample had completed grade 10-12 at high school (54%, 71/131), while over two-fifths (41%, 53/131) had obtained some form of tertiary education. Over three-quarters of pilots were Australian born (79%), with another 14% emigrating from the British and European region. The mean ($\pm$SD) height of the pilots was 179.8 ($\pm$6.6) cm, and their mean ($\pm$SD) weight 79.6 ($\pm$8.9) kg. The median body mass index of the pilots, calculated by the formula weight (in kilograms)/height (in meters squared) was 24.4 (IQR 20.0–30.5). Most pilots (86%, 113/131) were non-smokers. No major demographic differences were identified between responders and non-responders to the main survey.

One fifth of participants (20%, 26/131) had sustained a sporting injury to their back in the past while 18% (24/131) had previously injured their backs lifting heavy objects. Few pilots (6%, 8/131) reported either a family history of back problems or a history of whiplash injury. Two pilots had sustained previous vertebral fractures as a result of flight ejection while another twelve pilots reported 'other' previous injuries to their backs. The majority of pilots either jogged (81%, 105/130), swam (40%, 52/130), or cycled (31%, 40/130) for exercise.

The number of hours flown was classified two ways; first in terms of the total number of hours flown throughout the pilot's career, and second in terms of the total number of hours flown in either rotary wing or fixed wing aircraft. As expected, the pilots had logged substantially more rotary wing than fixed wing flying hours (Table 1), although fixed wing recreational flying was undertaken by nearly a fifth of all study subjects (19%, 25/131).

Prevalence and Nature of Reported Back Pain

Almost one-fifth (16%, 21/131) of pilots reported suffering regular back pain associated with flying, with another 28% (37/131) reporting "back discomfort" and 39% (51/131) "occasional" back pain (Appendix). Only 9% of pilots (12/131) gave a history of back pain that was unrelated to flying, with a minority of pilots (8%, 10/131) indicating they were pain free (Fig. 1). Most pilots who suffered back pain while flying attributed their symptoms to flying (85%, 93/109), with almost one third (30%, 39/130) believing that flying was detrimental to their health.

The majority of pilots described their pain as being either "aching" (63%, 78/123) or "dull" (25%, 31/123). Fewer reported it as a "numbing" (10%), "burning" (7%), "dragging" (6%) or "tingling" (2%) sensation. In the majority of instances the pain was felt in the lower back (86%, 106/123), although substantial proportions of pilots reported pain in their mid-back (21%, 26/123), buttock (25%, 31/123) or neck (29%, 36/123) regions. Fewer pilots complained of pain in either their shoulders (8%) or legs (9%). Aggravating factors included continued or intensive flying (24%, 28/117), poor posture or prolonged sitting (16%, 19/117) and jogging or strenuous exercise (11%, 13/117). The pain was relieved by stretching (61%, 74/122), rest or relaxation (30%, 37/122),

<table>
<thead>
<tr>
<th>No. of Flying Hours</th>
<th>Mean ($\pm$SD) Hours</th>
<th>Median (IQR) Hours</th>
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<tbody>
<tr>
<td>Rotary wing</td>
<td>1,613 ($\pm$1,529)</td>
<td>1,151 (560 to 2,280)</td>
</tr>
<tr>
<td>Fixed wing</td>
<td>400 ($\pm$672)</td>
<td>150 (99 to 300)</td>
</tr>
<tr>
<td>Total</td>
<td>1,998 ($\pm$1,730)</td>
<td>1,350 (850 to 2,800)</td>
</tr>
</tbody>
</table>
change of position (27%, 33/122), or exiting the aircraft (7%).

Pain was initially felt after a median of 2 h flying time (IQR 1.5–3.0 h). For a minority of pilots (7%) the pain was relatively short-lived, lasting less than 30 min. Most pilots, however, suffered back pain for significantly longer periods. For 40% (43/110) the pain lasted some 30 to 60 min, with an additional 22% of pilots (24/110) reporting pain duration from 1 to 4 h. Significantly fewer pilots reported back pain lasting either 4 to 12 h (12%), 12 to 24 h (11%), “days” (7%) or “months” (2%).

Back pain was not, however, felt consistently, with only 7% of pilots reporting back pain with “most flights.” However, the majority of pilots reported back pain associated with long flights (58%, 66/114), defined as a flight lasting longer than one hour, while a substantial number (40%, 46/114) reported pain associated with periods of intensive flying, defined as flying more than 20 hours per week (Appendix).

Approximately 40% of pilots (50/121) sought relief from a physiotherapist for their pain. One fifth (22%, 27/121) used heat treatment, 12% used simple analgesics such as aspirin, paracetamol or codeine or cold packs, while a similar proportion (12%) sought Chiropractic treatment.

Differences According to Aircraft Type

At the time of the survey the Iroquois UH-1H, Bell Kiowa 206B, Squirrel AS-350B, Black Hawk S-70A-9, Seahawk S-70B-2 and Sea King Mk 50A were all in service in the Australian Defence Force, with some pilots flying more than one aircraft type. At the time of the survey, most pilots were flying the Squirrel (50%, 66/131), Kiowa (44%, 58/131) and Black Hawk (36%, 47/131) helicopters, with over a quarter flying the Iroquois (28%, 37/131).

The majority of pilots (74%, 97/131) associated particular aircraft with either the initiation or aggravation of their back pain. The Iroquois and Kiowa helicopters were seen as being the most problematic, with 95% (35/37) and 74% (49/66) of pilots respectively flying these aircraft reporting problems specifically related to certain features. Table II summarizes the major problems identified by the pilots by aircraft type.

Around 40% of pilots (52/131) used some form of additional back support while flying, although the frequency of use depended on the type of aircraft flown. Around a third of pilots flying the Iroquois (27%, 10/37), Kiowa (31%, 18/58) and Black Hawk helicopters (30%, 14/47) used back supports, compared to 5 of the 9 pilots flying the Seahawk, and 5 of 12 pilots flying the Sea King. In contrast, less than 5% (3/66) of pilots flying the Squirrel reported using such supports.

Predictors of Back Pain

We were specifically interested in determining the predictors of back pain associated with flying. For this set of analyses, therefore, the “regular” and “occasional” back pain related to flying groups are differentiated from the “back discomfort”, “no back pain”, and “back pain not associated with flying” categories.

There were no associations between pilot back pain and height, weight, body mass index (BMI) or posture. The only significant association with back pain at the univariate level was with a history of prior back injury; people with back pain were significantly more likely to have injured their backs in the past than those without (66% vs. 47%, $\chi^2 = 4.14, p < 0.05$). Although there was no association between the number of flying hours and back pain in general, pilots who complained of neck pain had flown significantly more hours in rotary wing aircraft than pilots who did not (1415 rotary wing flying hours vs. 1028 rotary wing flying hours, Mann-Whitney U test 2.20, $p < 0.05$). Pilots who had flown more rotary wing hours were also more likely to complain of back pain associated with intensive flying—defined as flying more than 20 hours per week (1535 rotary wing flying hours vs. 765 rotary wing flying hours, Mann-Whitney U test 3.88, $p < 0.0001$).

Multiple logistic regression was used to determine the most significant predictors of back pain associated with flying. A theoretical model of predictors for back pain which included pilot age, education, BMI, posture, history of previous back injury and total number of rotary wing flying hours was developed. Amongst these variables, a past history of back injury was the only statistically significant risk factor to emerge. Based on this model, previous back injury more than doubled a pilot’s risk of back pain (Table III).

Effects of Back Pain on Flying Performance

More than half the respondents (54%, 67/123) reported that back pain had interfered with their concentration at some time while flying. A substantial number (16%, 20/124) admitted to hurrying a mission because of back pain, while a minority (7%, 9/124) had actually refused to fly because of back problems (Fig. 2). Only three pilots reported being aware of a potentially dangerous or hazardous situation arising from the effects of back pain.

DISCUSSION

This study has indicated that the majority of helicopter pilots (64%) in the Australian Defence Force suffer from
back pain. The prevalence of reported back pain, and characteristics of the study sample are similar to those observed in other overseas studies conducted on military personnel (2,5,9,10). Back pain in the ADF may have substantial impact on pilot performance, flying safety, and pilot health. Operational readiness may also be adversely effected if experienced pilots with back pain are downgraded and posted to non-operational units. It is known that two to three exemptions from flying duty are granted to helicopter pilots on the grounds of back pain every year (Army Aviation Career Adviser, Canberra. Personal Communication). However, there is no existing data on the number of pilots who have been permanently grounded or resigned because of back pathology.

We acknowledge that our estimates of back pain are based on self-report, and pilots are known to be reluctant to report back pain because of fear of flying restrictions (10,11). In the ADF, admitting to back pain may also jeopardize a pilot’s future employment opportunities or pension entitlements. This may partly explain the relatively high incidence of the more innocuous “back discomfort” associated with flying observed in the study. Indeed, several pilots who have resigned from the ADF are now pursuing compensation claims for back pain although they did not admit to this ailment during their careers (Senior Aviation Medicine Specialist, ARA, Personal Communication). The results of this study may, therefore, underestimate the true size of the problem. However, the fact that the prevalence of back pain unrelated to flying (9%) is similar to that found in studies of the general Australian community (1) provides some degree of face validity to the estimates.

Similar to previous studies (3,7,9–11,22), the majority of pilots reported transient back pain in the lower lumbar region. Almost one-third of helicopter pilots also reported neck pain, which may be at least partly due to the heavy equipment attached to the pilot’s helmet for night vision (and weighing up to 1.5 kg) or to the helmet itself. Supporting the head by using a back or neck rest, however, can increase the transmission of vibration to the head and neck area and so affect pilot visual acuity (4). In addition, pilots are generally required to hyperextend their necks in order to see over the instrument panel in the most cockpits. These factors would increase not only the discomfort, but also presumably the risk of flying induced fatigue and associated lapses in concentration. This is currently a vexed issue and there is an urgent need to develop a more lightweight helmet that reduces the strain on a pilot’s neck while flying. Further research on the relationship between night vision equipment and back pain is needed.

Other authors (19) have investigated the effect of back pain on flying performance with findings similar to those of this study. Our results suggest that there are potentially major occupational health and safety issues involved, with over 50% of pilots reporting that back pain had interfered with their concentration during flight at

**Table II. Proportion of pilots flying each aircraft type who implicated aircraft-specific features associated with back pain.**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Squirrel (n = 66)</th>
<th>Kiowa (n = 58)</th>
<th>Black Hawk (n = 47)</th>
<th>Iroquois (n = 37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seated posture</td>
<td>47</td>
<td>66</td>
<td>27</td>
<td>65</td>
</tr>
<tr>
<td>Shape of back cushion</td>
<td>47</td>
<td>52</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td>Seat shape</td>
<td>24</td>
<td>55</td>
<td>21</td>
<td>51</td>
</tr>
<tr>
<td>Vibration</td>
<td>---</td>
<td>52</td>
<td>17</td>
<td>65</td>
</tr>
<tr>
<td>Poor seat adjustment</td>
<td>---</td>
<td>62</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Position of cyclic pitch control</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>35</td>
</tr>
<tr>
<td>Pedal position</td>
<td>18</td>
<td>---</td>
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</table>

* Respondents could circle more than one answer for this question. Proportions <10% not reported.

**Table III. Predictors of back pain associated with flying among helicopter pilots.**

<table>
<thead>
<tr>
<th>Variable*</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.93</td>
<td>0.84–1.04</td>
<td>0.22</td>
</tr>
<tr>
<td>Education</td>
<td>0.48</td>
<td>0.21–1.09</td>
<td>0.08</td>
</tr>
<tr>
<td>BMI</td>
<td>0.61</td>
<td>0.27–1.36</td>
<td>0.23</td>
</tr>
<tr>
<td>Posture</td>
<td>1.33</td>
<td>0.60–2.95</td>
<td>0.48</td>
</tr>
<tr>
<td>Flying hours</td>
<td>1.00</td>
<td>1.00–1.00</td>
<td>0.11</td>
</tr>
<tr>
<td>Past back injury</td>
<td>2.63</td>
<td>1.11–6.23</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* Education coded: 0 = no tertiary education, 1 = tertiary education; BMI coded: 0 = not overweight, 1 = overweight; Posture coded: 0 = not hunched, 1 = hunched; Past back injury: 0 = no past injury, 1 = past injury.

Model Statistics: Hosmer-Lemeshow goodness-of-fit $x^2 = 10.0$, p > 0.05. Sensitivity = 88%, Specificity = 45%. False positives = 55%; False negatives = 12%.

**Fig. 2.** Major effects of back pain on flying performance.
some time. However, the frequency of these lapses in concentration is not known and is certainly an area that demands further study. Along with findings from other countries, our study also indicates that some military helicopter pilots are tending to hurry missions because of their discomfort, with only a minority being willing to refuse to fly a mission. These findings, however, relate only to peacetime flying activities, and whether they would affect pilot performance during active service cannot be determined from this study.

Most pilots sought relief from back pain using approved methods. More than 10%, however, sought Chiropractic relief, which is currently not accepted as an alternative mode of therapy by the Defence Force. Studies on the efficacy of alternative methods of treating back pain, and/or more effective back injury prevention/rehabilitation programs seem to be required.

The prevalence of back pain varied significantly with type of aircraft flown. The ergonomic design faults of the Kiowa helicopter are well known (4), and yet were flown by almost 50% of the study sample. Pilots highlighted a number of problems associated with the seating posture in both the Kiowa and Iroquois helicopters and had major concerns regarding the seat shape and vibration associated with these aircraft. The Kiowa was also highlighted for poor seat adjustment and the Iroquois for poor positioning of the cyclic-pitch control. On average, 4 out of around 70 Kiowa and Iroquois pilots request transfer to Black Hawk units every year (Army Aviation Career Adviser, Canberra. Personal Communication). In contrast, few problems were identified with the Squirrel helicopter, which may be explained by its role in the ADF as a training aircraft. The Squirrel is mainly used to train young pilots; sorties are brief (1.0–1.5 h) and are performed in a non-operational environment. Most students have relatively low accumulated flying hours and instructors are able to structure their own flying schedules. However, this lack of association may also be a function of improved design, or a function of “survivor” bias in terms of those instructors who were able to continue piloting them.

While a number of researchers have called for improved ergonomic design or refurbishment of helicopter cockpits, most recognize that realistically we can expect only minor changes until the present fleets need to be phased out (4,11). Because of this, some Defence Forces supply lumbar supports to helicopter crew as part of a strategy to reduce the incidence and prevalence of back pain (4). Although this is not routinely done in the Australian military forces, almost 40% of pilots had nevertheless asked to be supplied, or had been advised to acquire, back supports while flying. Included among these were pilots who flew the Black Hawk and Seahawk helicopters, two aircraft whose seats are already fitted with back support devices. The reasons for this are unclear. They do suggest, however, that at least some pilots are finding these supports beneficial.

Our multivariate model indicates that a previous history of back injury was the most important predictor of back pain among rotary wing pilots. With statistical significance set at the conventional p < 0.05 level, there is a 1 in 20 probability that this finding may be due to chance. However, given that this association was found to be significant in the various multivariate models we developed, it is likely to be real. This has important implications both for selection procedures and back injury rehabilitation programs among Defence Force personnel. It also provides clear messages about the importance of back injury prevention programs. However, although the model has high sensitivity (88%), it has relatively lower specificity (45%), indicating that while the model serves as a relatively good mechanism to rule out people who are unlikely to have back pain, it will tend to overestimate the number of people who do. This is reflected in the relatively high false positive but low false negative rates. There are clearly other factors that are not included in the model that also contribute to back pain.

The fact that pilot posture was not a significant factor for back pain was surprising, but not necessarily inconsistent, given that most pilots reported having adopted the “hunched” body posture typical of helicopter flying. Thus, this variable might not have discriminatory power in the current study. Moreover, two in every five pilots used some form of back support which may have modified the usual consequences of adopting such a posture. Although age was not a significant risk factor for back pain in this sample, the study population as a whole was relatively young, with the oldest pilots being in their early forties. This is largely because older pilots in the ADF tend to hold command and staff appointments which entail a very significant reduction in operational flying hours.

The response rate for this cross-sectional survey was 66%, which is reasonable for surveys conducted among military personnel. This was partly because a large proportion of pilots who had been sent questionnaires were posted overseas at short notice prior to completing and returning their forms. It is also possible, however, that some pilots may have been unwilling to participate in the study for fear of being grounded should the Defence Force become alerted to the fact they had a health problem. An attempt was made to contact all non-respondents where possible (no attempt was made to contact those pilots who were overseas on active service). Although only approximately 30% of initial non-respondents completed an abbreviated questionnaire (21/69), there appeared to be no significant differences between the main study sample and the non-respondent sample in terms of age, height, weight, and BMI. However, the prevalence of reported back pain and back discomfort in this group of non-responders to the main study (48% and 19% respectively) was actually lower than that reported by the participating study sample.

Within the Australian Defence Force, any chronic health problem, including debilitating back pain, would usually result in a restriction of flying duties, transfer to a desk job or discharge from the services. No attempt was made to contact these individuals. As a result the study may suffer from a “survivor” bias in terms of the pilots remaining on active flight duties who were selected for the study. This is a problem seen with all cross-sectional surveys, and usually results in an underestimation of the magnitude of the health problem in question. It can also lead to difficulties identifying the true nature of the most important risk factors leading to personnel loss and disability. There is an urgent need for a longitudi-
CONCLUSIONS

There is a high prevalence of back pain among Australian military helicopter pilots and this is potentially jeopardizing military operational readiness, flying performance, and pilot safety. A number of pilots have concerns about the Kiowa and Iroquois helicopters in particular, and the ergonomic design faults in these aircraft need urgent attention. A significant association between back pain and a prior history of back injury was observed, and has important implications for pilot selection and rehabilitation programs.

In an ideal world, poorly designed aircraft would be replaced by new ones designed according to ergonomic guidelines. In reality, however, the cost of doing so is likely to be prohibitive, and therefore, alternative, more cost-effective solutions need to be found. In the short term the most practical solutions would appear to be the more widespread use of lumbar supports in aircraft; introduction of lightweight helmets; and improved back injury prevention and rehabilitation programs. There is a real need to examine in greater detail a number of health and safety issues relevant to the Australian Defence Force.

APPENDIX. SELECTED QUESTIONNAIRE ITEMS.

1. Do you get back pain? [Circle response(s)]
   a) No
   b) No, but I do experience back discomfort related to flying.
   c) Yes, regularly when/after flying.
   d) Yes, occasionally when/after flying.
   e) Yes, unrelated to flying.

2. If your back pain or discomfort is related to flying, when do you get it? [Circle response(s)]
   a) On or after some/most flights.
   b) On or after flights that last less than an hour/more than an hour.
   c) During or after periods of high workload or hard concentration while flying.
   d) During or after a prolonged period of intensive flying (e.g. more than 20 hours of flight per week).
   e) Other: _______________________

3. Have you ever refused a flying mission due to back pain or discomfort? [Circle response]
   a) Yes
   b) No

4. Have you ever hurried a flying mission due to back pain or discomfort? [Circle response]
   a) Yes
   b) No

5. Has back pain or discomfort ever interfered with your concentration while flying? [Circle response]
   a) Yes
   b) No

6. Do you know of any instance(s) in which back pain/discomfort has resulted in a dangerous or potentially dangerous situation during a flying mission? [Circle response]
   a) Yes
   b) No

REFERENCES