Noise Induced Hearing Loss in Military Helicopter Aircrew - A Review of the Evidence

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SUMMARY: Noise Induced Hearing Loss (NIHL) has been recognised for some time. In the military environment one group of personnel at risk are Army helicopter aircrew who are exposed to continuous noise levels of up to 100 dB(A) in flight. The evidence for the damaging effect of this occupational noise is reviewed and some of the difficulties in drawing conclusions are highlighted. The current protection offered for the Mk 4 helmet is discussed and the incorporation of Active Noise Reduction (ANR) is suggested as a likely way of ensuring that the in-flight noise exposure in Army aircrew is kept as low as possible.

Introduction

The detrimental effects of noise on hearing have been known for a long time. In 50 AD Pliny the Elder reported in his Natural History that people living near one of the roaring cataracts of the Nile became hard of hearing. This is perhaps one of the earliest references to the detrimental effects of continuous noise exposure. Ramazzini (1) noted in 1713 that coppersmiths hammering copper 'have their ears so injured by this perpetual din that workers of this class become hard of hearing and, if they grow old at this work, perpetually deaf, highlighting the deleterious effects of repetitive impulsive noise. Despite the awareness that exposure to noise was detrimental to hearing, very little was done to reduce the noise or protect the workers, as shown in the Chief Inspector of Factories and Workshops' Annual Report (2) in 1934, which commented, 'Only in comparatively few cases do the workers appear conscious of any inconvenience sufficient to justify the wearing of ear protection'.

Since the Second World War awareness of hearing damage caused by noise has increased greatly, culminating in the Noise at Work Regulations 1990 (3). These regulations set two action levels for noise exposure. The first action level for an 8 hr exposure is 85 dB(A)Leq, above which hearing protection must be available if requested and the second is 90 dB(A)Leq, above which hearing protection must be used and the noise level must be reduced as far as reasonably practicable. The regulations apply to all workers in the United Kingdom, including service personnel and civilians employed by the Ministry of Defence, who are exposed in the military environment to a mixture of impulsive (gunfire) and continuous (machinery) noise.

Military aircrew are one of the groups exposed to continuous noise above the limits recognised to cause hearing damage. One of the first studies into deafness in aviators was carried out in 1939 and showed a hearing loss related to exposure to piston engine noise which was diminished by the use of hearing protection (4). Further studies were carried out and by 1953 it was suggested that

90 dB should be the danger level for noise exposure (5). With the advent of high power turbine and jet engines and the requirement for faster, lighter and more manoeuvrable aircraft the noise load has continued to rise.

A good level of hearing acuity is important in pilots and aircrew because, after visual input, auditory information provides the greatest degree of assistance in flying the aircraft safely. Despite the noisy environment the aircrew need to use an extensive communication system, from the personal communication within the cockpit (intercom) to the radio systems (in the military environment this may involve the concurrent use of three radios) and the auditory warning signals such as the radio altimeter and the radar warning receiver. This equipment is used during flight when the aircrew are usually involved in other activities which may be highly stressful. In addition to this the quality of the radio information may be poor with interference and static noise partially masking the messages.

In view of the difficulty in assimilating auditory information it would not be unreasonable to wish to avoid exacerbating the problem of impaired hearing, especially as in-flight errors may be fatal. One of the few studies to look at the effect of impaired hearing on flight safety was done in 1981 (6). The accident rates were examined for 70 US Army aviators who had impaired hearing below the normally acceptable limit but were still flying following a medical examination and issue of a waiver. They found no relationship between accident rates and impaired hearing in this group and concluded that the evaluation appeared sensitive enough to recognise those who were medically safe to continue flying, as their acquired flying skills appeared to compensate for the hearing loss.

Risks and Sources of Noise Exposure

Aircrew have some noise exposure within squadron buildings and when carrying out daily inspections on the aircraft. However the principle exposure occurs when flying and is predominantly low frequency and

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mechanical in origin. For example, in the 'Lynx' the lower frequencies (0 - 250 Hz) are dominated by main and tail rotor noise, while the mid-frequencies (300 - 4000 Hz) are dominated by gearbox noise (7). In 1977, in a study of military helicopter aircrew, the average 'noise at the ear levels' were measured in a selection of Service helicopters and found to be 97 dB(A) for the 'Gazelle', 99.8 dB(A) for the 'Scout' and 99.9 dB(A) for the 'Puma' (8). A further survey in 1981 showed average noise at the ear levels in the 'Lynx' to be 100 dB(A) (7).

The other major sources of noise are both wanted and unwanted signals from the communications systems. In 1977 work at the Royal Aircraft Establishment showed that aircrew are exposed to communications noise from an average of 40% of each sortie, increasing the noise dose from the aircraft noise alone by about 6dB (9). Since then, an increased number of in-flight radios and acoustic warning signals have been fitted, increasing the noise load from the communications systems.

The effects of noise exposure at these levels have been studied in several countries with a variety of conclusions

between hearing loss and number of years spent flying (12). In 1985, however, Ribak et al, studying 77 personnel in the Israeli Air Force, had shown a strong relationship between age and hearing threshold shift while flying time and aircraft type were only poorly related (13). One of the most recent studies carried out in the UK military environment was by Jones in the Royal Navy (14). This showed that NIHL did not appear to be a problem for aircrew with less than ten years flying experience, given the current number of hours flown each year.

The differing conclusions drawn from the studies cited above show some of the difficulties in trying to draw a straightforward relationship when there are several influencing factors. The principle confounding factor that needs to be taken into account is the natural effect of presbycusis. There is also the effect of improved hearing protection provided by modern aircrew helmets combined with a reduction in the number of hours spent flying due to financial and training constraints, which may result in a different noise dose over the years. The

Table 1
Summary of Studies of Hearing Loss in
Military Aircrew

Year	Author (First only)	No. in Study	Mean Age (Years)	Av. Flt Hours	Correlation with Hearing Threshold Shift			
					Age	Years Flying	Total Flight Hours	A/C Type
1982	Edgington	200	31	1000- 1500	+	+	-	-
1983	Peters	145	32	2000- 3000			+	
1985	Ribak	777*	27	1000- 1500	+++		+/-	+/-
1988	Fitzpatrick	178	32	1000- 1500	+/-		+++	-
1988	Jones	184*, \$		1000- 1500	-	+		-

*Both Rotary and Fixed Wing Aircrew

\$ Includes Pilots, Aircrew, Observers, Photographers and Maintainers.

+++ = Strong association
+ = Slight association
+/- = Minimal association
- = No association

(Table 1). In 1983 a study of US Army aviators at Fort Rucker showed an association between the number of flight hours and an increase in hearing loss (10). A study of 178 helicopter pilots in the US Army by Fitzpatrick in 1988 concluded that hearing loss in aviators was a function of their noise exposure, as expressed by the number of flying hours completed (11). A similar earlier study of 200 helicopter aircrew in the Army Air Corps carried out by Edgington has also shown a relationship

technological advancements in the methods for measuring hearing by audiograms have also changed over the same period, automatic recording and self-calibrating audiometers in acoustically screened booths replacing recording machines. When the effects of exposure to impulsive noise from firing military weapons are added to the final relationship between hearing impairment and military flying becomes even more difficult to verify.

Hearing Protection

The aircrew helmet provides both impact and acoustic protection and in common with all equipment used in aircraft has to undergo rigorous testing to achieve airworthiness clearance. The noise attenuation characteristics for the Mk 4 helmet, currently in use with British military aircrew, have been extensively studied (15, 16, 17). The noise attenuation varies with frequency as shown in Figure 1 (17).

(Attenuation in Decibels, Frequency in Hertz)
Fig 1. Noise Attenuation Characteristics of the
Mark 4 Helmet

However, as described above, the helmet is also a source of noise from the communications loudspeakers in the earcups. One way of reducing the unwanted communication noise is with electronic filters, however this has the disadvantage of reducing the intelligibility of the information being passed. To get around this problem active noise reduction (ANR) systems have been developed for use in aircrew helmets, in which the acoustic field inside the earcup is detected and an antiphase signal fed back into the cup to cancel out some of the sound energy. This system has been shown to work particularly well in the low frequency range from 40 Hz to 1 kHz, with the mean peak attenuation level of 22.5 dB occurring in the 315 Hz 1/3 octave band (18). As shown in the graph in Figure 1, the low frequency noise attenuation of the Mk 4 helmet is not good, ranging from nil to 33.4 dB over the same frequency as above, with a mean peak attenuation level of 18.3 dB at 315 Hz. The combination of the Mk 4 helmet, providing good high frequency protection and ANR increasing the low frequency attenuation ensures that the wearer receives maximum hearing protection across all frequencies.

As with all forms of personal protective equipment (PPE), the hearing protection of the helmet will be compromised by poor fitting and incorrect use. All aircrew have their helmets fitted by trained staff and have to have the fit regularly checked as part of the routine

helmet servicing. Under certain circumstances aircrew are allowed to wear prescription glasses for flying. In these people there is a potential for compromising the earcup seal with the side arm of the glasses, though this problem is minimised by using glasses with a low profile. Another cause of diminished protection is excessive helmet movement on the head. When aircrew are using night vision goggles (NVG) the equipment is mounted on the helmet, increasing the weight and moment around the head. NVGs also reduce the field of vision for the wearer, making increased head movements a necessity for safe off-flight observations. Both of these factors are unavoidable aspects of current flying and are addressed by the regular servicing and inspection of the helmets.

Conclusions

Army aircrew are operating in an extremely noisy environment in which the principle form of hearing protection remains the use of PPE. In the past the level of protection provided in this way has not been sufficient to prevent NIHL. However more recent studies, such as those by Ribak and Jones (13, 14), have shown that NIHL in aircrew is becoming less marked and more difficult to differentiate from the natural process of presbycusis.

This is principally due to improved helmet design and awareness of the need to comply with hearing protection measures. Part of the increased awareness is due to the annual aircrew medical examination which includes a pure tone audiogram. The continuing Army Hearing Conservation Program (19) also promotes a general awareness of the detrimental effects of noise exposure and the irreversible nature of the hearing damage caused.

The mechanical noise generated by helicopters cannot be greatly altered as the weight burden of any significant amount of sound insulation would cause an unacceptable loss of aircraft performance. Therefore the only realistic method of reducing noise exposure to the aircrew is through the use of PPE, the aircrew helmet, which has been correctly fitted and serviced. The combination of good high frequency attenuation provided in the current Mk 4 helmet together with the low frequency cancellation available through the use of ANR provides maximum protection to the aircrew. In addition to these measures, the constraints of flight training time and the continuing development of flight simulators should further reduce the noise exposure for aircrew to level where the only predictable hearing loss will be due to presbycusis. The long term aim therefore should be that NIHL in military aircrew will become an area of historical interest rather than current concern.

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