A Self-Controlled Trial to Evaluate the Use of Active Hearing Defenders in the Engine Rooms of Operational Naval Vessels

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ABSTRACT

Introduction: Active Hearing Defenders are established hearing protectors with in-built electro-acoustics that shut-off ambient noise while allowing effective communication between users.

Methods: A blinded, self-controlled trial was conducted among naval servicemen to compare the effectiveness of two types of active hearing defenders (Howard-Leight Thunder™ and COM-55) in relation to passive hearing defenders in an operational environment.

Results: Subjects felt that the active hearing defenders were more comfortable, durable, and that the active hearing defenders helped them work better. When subjects were tested with a speech discrimination battery (Central Institute of the Deaf, Spondee Word lists), there was a significant difference (p value of 0.04, using the Kruskall-Wallis ANOVA test) between the two active and the passive defenders. However, no significant difference was found between the two types of active hearing defenders.

Conclusion: Active hearing defenders are an acceptable and efficacious means of hearing protection in noisy environments.

Keywords: active hearing defenders, hearing conservation programme, noise induced deafness, passive hearing defenders, speech discrimination battery

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INTRODUCTION

Noise-induced deafness (NID) is the leading occupational disease in Singapore[1,2]. Controlling noise levels at its source is regarded to be the best way of preventing noise-induced deafness in industry. However, such controls are not always feasible and it has been recommended that suitable hearing protectors be employed as part of a Hearing Conservation Programme to reduce the incidence of noise-induced deafness[3]. Noise mapping studies were done on board Republic of Singapore Navy ships in 2000. The noise levels in the engine rooms were found to be consistently above 85 dBA[4] at normal cruising speeds. Servicemen working in the engine rooms of ships in the Republic of Singapore Navy are therefore at risk of developing high-frequency hearing loss as a result of exposure to high noise levels[5], and are required to wear good hearing protectors when working in the engine room.

Earplugs and earmuffs have been widely used. However, these cut down all types of noise, both wanted and unwanted noise, such that users are unable to hear others speak and communication at work becomes a problem. This compromises safety and also often results in users removing the ear protectors periodically in order to hear others speak. The use of active hearing protectors allows effective communication[6] by selectively filtering out certain types of noise (e.g. loud impulse noise or harmful level of noises of certain frequencies) thus allowing speech sounds to be heard better. There are two types of active hearing defenders, namely: active level dependent protectors and active noise canceling protectors.

Active level dependent hearing protectors allow sound at non-harmful levels to be processed at unity gain. However, if ambient noise levels are above 85 dBA, the circuitry is clamped down so that the user receives the full protection of the hearing defender. Active noise cancellation inverts the phase of the noise to cancel it[7]. Variants of the two types which selectively attenuates noise of different frequencies are also available. Two sets of active hearing defenders, the Howard-Leight Thunder™ and the COM-55, were procured for evaluation. The COM-55 is an active level dependant hearing protector whereas the Howard-Leight Thunder™ is a active noise canceling protector which is able to selectively reduce lower frequency of noise.

The objectives of the study were to evaluate the subjective comfort, durability, user acceptance, speech reception and noise reduction capability of the active hearing defenders versus the passive hearing defenders;

Table I. Subjective assessment of hearing protectors.

	COM - 55 hearing defenders	Howard-Leight Thunder hearing defenders	Conventional passive hearing defenders
Is the hearing protector that you used comfortable?	7.19	7.00	5.92
Are the hearing defenders durable?	6.73	6.96	6.54
Can the hearing protectors reduce noise effectively?	6.88	7.15	6.19
Do the hearing protector help you work better?	6.81	6.77	6.08
Can you hear your colleagues speak while wearing the hearing protectors?	5.27	5.12	4.27
On a scale of 1 to 10, how would you rate the hearing protectors?	6.81	6.66	5.65

Table II. Objective testing with hearing protectors in ship engine room using a speech discrimination test.

	COM - 55 hearing defenders	Howard-Leight Thunder hearing defenders	Conventional passive hearing defenders
Missile gun boats (MGB)	3.6[1]	3.6	1.0
Patrol vessel (PV)	5.7	7.0	4.3
Landing ship tanks (LST)	8.8	11.2	3.0
Overall performance	10.2	10.1	4.3

[1] Average number of words identified correctly during the speech discrimination test

and to evaluate the objective speech reception capability of the active hearing defenders versus the passive hearing defenders.

METHODS

The trial was carried out on four ships of different classes, chosen based on operational availability. A total of 18 servicemen who worked in the engine room were selected for this study. While out at sea, these personnel had to conduct periodic rounds in the engine room to monitor and operate the various mechanical devices in the engine room. All were men, regular servicemen in the Navy, and their age ranged from 20 to 25 years old. The study group had no prior history of noise-induced deafness, and had normal pure-tone audiometry[8,9] done a few days prior to the trials. The trial was conducted at sea to test the performance of the hearing defenders under operational conditions during which the ship was running at normal cruising speed. The trial was carried out over a period of six weeks from 5th December 2001 to 21st January 2002.

During the trial, each serviceman was required to wear the COM-55 hearing defenders for one hour, the Howard-Leight Thunder™ hearing defenders for one hour, and conventional ear protectors for one hour. We attempted some blinding whereby they were not told of the differences between the three types of hearing defenders. However, no attempt was made to disguise the three defenders so that they had looked identical. The passive attenuation of the three hearing defenders were similar, ranged from 21dB to 24dB, and were not deemed to be a confounding factor .

While wearing the three types of hearing protectors, their word recognition and hearing acuity were tested objectively using a speech discrimination battery, the W-1 Spondee Word lists (Central Institute for the Deaf)[10]. This battery consisted of 36 bi-syllabic words used by audiologists and is designed to test speech reception. As all the subjects had normal hearing, bi-syllabic words were used rather than phonetically balanced words. This was because bi-syllabic words had equal stress placed on each syllabus, homogeneous with respect to audibility, and were therefore easier to administer clinically. On the other hand, phonetically balanced words are more useful for speech discrimination for words of different frequencies, and more suitable for assessment of hearing impairment and the usage of hearing aids.

To ensure that the tests were properly administered and to prevent observer bias, two medical orderlies (medics) administered the tests onboard all four vessels. The medics were trained to repeat the words at the same intensity and with the same stress placed on each syllabus. As the words used were already chosen with a homogeneous stress of each syllabus, their task was made easier. The same two medics were used across the different ships. The words were read by the medics to the subject at an arm's length with the subjects facing away from the medics to prevent

them from lip reading. Upon hearing the words, the servicemen would write them down on a piece of paper. Three different word sets were used for each of the three hearing protectors. Following the three-hour study period, servicemen were also required to complete a questionnaire that was designed to subjectively compare the three types of hearing protection in their work environment. Various aspects of the hearing protector such as comfort, durability, speech discrimination, acceptability and effectiveness (Table I) were scored on a one to 10 scale, with one being the worst result and 10 being the best result possible.

RESULTS

The noise level of the engine room in the ships were generally the same for two classes of ships, i.e. the landing ship tanks (LST) and the patrol vessel (PV), and varied between 98 to 103 dBA. The noise level for the missile gun boats (MGB) were louder at 120dBA. However, in all three classes of ships, the results showed that both types of active hearing defenders performed better in both subjective and objective assessments, compared to the older passive hearing defenders.

In the objective assessment with the speech reception battery, users averaged 10 out of 36 words correct for the active hearing defenders compared to four out of 36 for the passive defenders (Table II). To compare between the three sets, the mean score of the speech discrimination test obtained for each of the three sets was analysed. Statistical analysis was conducted using SPSS and the Kruskall-Wallis ANOVA test. The results showed that there was a significant difference (p value of 0.04) between the two active hearing defenders and the passive defenders. However, no significant difference was found between the two types of active hearing defenders. This could have either been because the numbers assessed was small, or that there was truly no real difference between the two types of active hearing defenders. We had chosen to combine the scores obtained for each of the hearing defenders type for the three classes of ships together. This was because "ship class" was not deemed to be a confounding factor despite the different level of noise since the active hearing defenders tested in the MGB which had the loudest noise level also performed better.

In the subjective testing, users felt that the active hearing defenders were more comfortable, more durable and more effective in reducing the noise in the work environment. Furthermore, users felt that the active hearing defenders helped them work better and allowed for more effective communication with their colleagues in noisy environments (Table I). As this was descriptive in nature, no statistical analysis was attempted.

DISCUSSION

Our results demonstrated that the active hearing defenders were better than normal passive hearing defenders in that it allowed better word discrimination. With the active hearing defenders, users could get only an average of 10 words out of 36 words correct, compared to four words out of 36 words when they used passive hearing defenders. The strength of the study was that it was self-controlled and therefore took into account individual variability in hearing. However, it could have been improved if efforts were made to blind the study group by making all three types of hearing defender identical. The fact that the noise level of the three classes of ships were not identical did not confound the study and invalidate the statistical application of the results since in all three classes of ships, the active hearing defenders had performed better then the passive hearing defenders.

However, although the word discrimination using the active defenders was still better in the MGB, it was not as good as that in the other ships (3.6 words in the MGB versus 5.7 and 8.8 words in the PV and LST, respectively). This would no doubt have diluted the overall word discrimination score when using the active hearing defenders. Sensorineural deafness as a result of exposure to high intensity noise is irreversible[11]. Naval servicemen working in the engine rooms of our ships are exposed to loud noise for a long duration. Thus, to reduce disability and to improve operational readiness, hearing protection and hearing conservation measures are imperative. Even though many types of hearing protectors, including earplugs, are available to workers, their success is confounded not only by their noise reduction rating but also by the workers' attitudes, comfort and durability.

Active hearing defenders are established hearing protection devices. Although more costly than conventional hearing protectors, the results from this study are encouraging. In this study, active hearing defenders have been shown to be better than conventional ear muffs in reducing background noise, improving hearing acuity and communication in the noisy engine room compartment. This study also shows that the active hearing protectors employed were comfortable and in general, well-accepted by their users. Although at present, cost may be a factor in the widespread use of these hearing defenders, it is expected that with improvements in active hearing defenders, in particular with the size of the circuitry, active hearing protectors will be more affordable for industrial use.

It is conceived that the use of active hearing defenders may be extended to industries in which workers are exposed to high noise levels yet requiring frequent on-job communication between workers. These include shipbuilding and repair, metal industries and other military units such as artillery formations. Other than the employment of hearing protectors in noisy environments, it must be remembered that the prevention of morbidity from noise-induced deafness in industry depends on a range of interventions including engineering design, worker and employer education, surveillance and notification, and regular audiometric testing of workers in noisy environments[12].

In conclusion, active hearing defenders are an acceptable and efficacious means of hearing protection in noisy environments and may be superior in workplaces where both noise reduction and effective communication to preserve normal operations is required. This study is however limited by the small number of participants. As no significant difference could be found between the Howard-Leight Thunder™ and the COM-55 hearing defenders, follow-up studies should be undertaken to compare the efficacy of different active hearing defenders and in addition, to further define the use of these active hearing defenders in the area of industrial operations.

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