Effect of basic military training on hearing in the Singapore Armed Forces

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ABSTRACT

Introduction: In the military service, hearing is at risk through exposure to impulse noise from firing and detonations. This study aims at looking into the consequences of military training on hearing acuity, as it would be useful to confirm the effectiveness of the hearing conservation programme in the Singapore Armed Forces.

Methods: A self-controlled study of 118 Singapore military conscripts was carried out, using questionnaires administered by trained personnel and pure tone audiometric assessments performed for both ears. The questionnaire and audiometry were done at the start of basic military training (BMT), with follow-up audiometry done at the end of BMT and one year into vocational military training (VT).

Results: 33 military conscripts were excluded subsequently in latter phases of the study. Of the 85 remaining conscripts, 16.5 percent of the study population were found to have abnormal audiograms at the start of BMT. At the end of the BMT phase, the percentage of enlistees with abnormal audiograms was 9.4 percent. By the end of one year of VT, the percentage of enlistees with abnormal audiograms was still 9.4 percent. Analysis of the differences in number of enlistees with hearing loss was done with the McNemar's test, and was found to be statistically insignificant (p-value equals 0.238).

Conclusion: The prevalence of 16.5 percent abnormal audiograms at the pre-BMT stage is probably related to unfamiliarity with the audiogram testing and/or "temporary threshold shift" effect. There was no significant difference in the number of enlistees with hearing loss upon enlistment and after one year of military training in this cohort of soldiers.

Keywords: audiometry, basic military training, hearing loss, military, pure tone audiometry

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INTRODUCTION

Hearing loss induced by noise initially affects high-frequency hearing, extending with time to lower frequencies that are more important for the perception of speech. Deteriorations are often subtle over the years before difficulty in hearing becomes noticeable. It is possible that early, asymptomatic noise-induced damage will eventually increase the severity of presbycusis, the predominant cause of hearing handicap and need for hearing aid. For the exposure to the same level of noise, there is variability in the occurrence and degree of permanent hearing loss among individuals.[1] In the military service, hearing is at risk through exposure to impulse noise from firing and detonations. Henderson and Hamernik have described that effects of impulse noise can interact with background continuous noise to produce greater hearing loss than would have been predicted by the simple sum of the individual noises.[2]

Singapore has a system of military conscription for men. On enrolment for National Service at the age of 18 years, a medical examination forms the basis for assignment within the armed forces, or in some cases, exemption. The men undergo basic military training (BMT) for three months before proceeding to advanced combat training (vocational training [VT]). They are then deployed into combat units. The total duration of military service is two years. The Singapore Armed Forces (SAF) has implemented a strong system of occupational health and safety, and inculcated a strong culture of safety among the military commanders and soldiers. An earlier study done by Toh et al found a prevalence of hearing loss of 3.6% among the recruits at enlistment.[3] Studies done earlier by Gold et al revealed 33.0% noise-induced deafness in the high frequency range (6 kHz) in 1,000 recruits after four months of BMT.[4] However, there was no long-term follow-up to the group.

A very strong culture of occupational health and safety already exists among the military commanders in the SAF. A hearing conservation programme has been set in place to identify and reduce noise hazards. Notwithstanding this, a study to look into the consequence of military training on hearing acuity would be useful to confirm the effectiveness of the hearing conservation programme. This study forms the first part of a two-year study. Two cohorts of military servicemen would be followed-up from enlistment till they complete their military training in two years. The first part would be looking into the effects of BMT on hearing

Table I. Results of audiometric assessment by right and left ears and different frequencies.

Ear	Frequency (kHz)	Audiometric scores (mean ± SD)			p-value*
		Pre-BMT	Post-BMT	VT	
Right	0.5	21.57 ± 6.26	22.78 ± 5.69	21.45 ± 6.94	0.096
	1.0	15.99 ± 4.63	16.63 ± 5.03	15.81 ± 6.05	0.323
	2.0	12.38 ± 5.69	13.49 ± 5.91	13.31 ± 6.50	0.934
	3.0	11.22 ± 6.05	11.92 ± 6.74	11.74 ± 7.19	0.940
	4.0	9.53 ± 7.73	8.20 ± 7.35	10.06 ± 7.57	0.451
	6.0	8.08 ± 7.67	10.35 ± 8.17	10.35 ± 7.50	0.012
Left	0.5	22.50 ± 7.14	21.80 ± 5.28	20.17 ± 7.53	0.071
	1.0	17.44 ± 5.90	16.86 ± 4.77	16.23 ± 5.86	0.356
	2.0	14.53 ± 6.36	14.30 ± 5.97	14.19 ± 6.51	0.193
	3.0	13.31 ± 6.36	13.49 ± 6.52	13.66 ± 6.45	0.603
	4.0	10.41 ± 8.22	11.86 ± 7.12	11.28 ± 7.24	0.064
	6.0	10.52 ± 9.03	9.88 ± 7.70	13.43 ± 7.90	0.008

* p-value for one-way ANOVA

Pre-BMT: pre-basic military training; post-BMT: post-basic military training; VT: one year after vocational training

loss and the next part would be following the two cohorts (Infantry and Armour) for the entire period of two years. The intent is to compare hearing loss, if any, among the two vocations. The aim of this study is thus to provide an indication as to whether BMT, and subsequent VT, have an effect on the hearing of the enlistees in the Infantry and Armour vocations of the SAF.

METHODS

Screening audiometry was performed for military recruits when they began their BMT programme (pre-BMT) and after completion of the programme (post-BMT). During the first week of enlistment when the testing was done, there was no prior exposure to firearms or explosions. The BMT programme conducted for both Armour and Infantry vocations are identical. The age range for the enlistees was 18–22 years. After exclusions were made for measurements performed only at the start or end of the BMT programme, 118 out of the cohort of 262 enlistees who remained (45.0%), fulfilled the criteria of having completed BMT and had both pre- and post-BMT audiometry done. A further 33 enlistees were excluded by the end of the study, leaving 85 (72.0%) enlistees who had audiometry done pre-BMT, post-BMT, and a year into VT.

Audiometric tests were performed with a screening audiometer at 0.5, 1, 2, 3, 4 and 6 kHz. To encourage maximum participation, the audiometry test and questionnaire were conducted in the military camp. As no soundproof booth was available, the measurements were taken in the quietest possible room. A criterion of 40 dBA or less was required for the room to be acceptable for performing the audiometry. To further reduce interference from background noise, the TDH-39 headsets used were covered with full-cup muffs in order to cut off an additional 20 dBA from background noise. An on-site self-test was done by the testers prior to the audiometry to ensure that the frequencies tested could be heard in the room. All enlistees had a loud-noise-free period of 48 hours prior to audiometry so as to control for possible temporary threshold shifts.

Hearing threshold worse than 25 dB in either ear is defined as hearing loss. Hearing loss can be either in the low frequencies (0.5–2 kHz) or in the high frequencies (3–6 kHz). For the analysis of this study, low frequency hearing loss was defined as mean hearing threshold > 25 dB in frequencies 0.5, 1 and 2 kHz. High frequency hearing loss was defined as mean hearing threshold > 25 dB in frequencies 3, 4 and 6 kHz. A supervised questionnaire was administered to every recruit each time prior to each of the audiometric examinations. The questions administered included personal particulars (age, gender, ethnic group and highest education), social history (deep-sea diving, smoking status, alcohol intake, use of portable audio players such as discman/walkman/MP3 player, and visits to discotheques), and medical history (including diabetes mellitus, mumps, hearing loss, ear discharge, ear ache, tinnitus and vertigo). Potential exposure to ototoxic drugs was noted (history of pulmonary tuberculosis treatment, radiotherapy, usage of aminoglycoside), as well as family history of hearing loss.

RESULTS

Of the 118 servicemen, 59 (50.0%) smoked. Of the smokers, 3 (5.1%) smoked for ten years or more before entering military training. 9 (15.3%) had been smoking for 7–9 years and 30 (50.8%) had been smoking for 4–6 years. The remaining 17 (28.8%) had smoked for less than three

years. 74 (62.7%) drank alcohol and 49 (66.2%) of the drinkers had done so for less than three years. The average number of times they drank was 1.59 times per week. 100 (84.7%) used portable audio players. The average number of hours per session of audio playing among this group was 1.79 hours per day. 65 (55.1%) visited discotheques. Of these, the majority, 53 (81.5%) had visited discos for less than three years, while 11 (16.9%) had visited discos for 4–6 years and only 1 (1.54%) had visited discos for 7–9 years.

In the study population, 14 (16.5%) individuals were found to have abnormal audiograms at the start of BMT. This percentage includes those with bilateral and unilateral hearing defects. At the post-BMT phase, the number of enlistees with abnormal audiograms was eight (9.4%). By one year into VT, the number of abnormal audiograms remained at eight (9.4%). Analysis of hearing thresholds of the study population at the lower frequencies (0.5–4 kHz) pre- and post-BMT showed no significant differences in the average means in the two groups ($p > 0.05$, one-way analysis of variance [ANOVA] test of homogeneity of variances). However, at 6 kHz, there were significant differences in the mean hearing threshold between pre- and post-BMT audiometric scores in the right ear ($p = 0.022$). It should, however, be noted that although there were significant differences in the numerical value of the hearing thresholds, only one subject had clinically significant hearing loss, thus the actual significance of this finding is questionable.

Comparing means of hearing threshold values pre-BMT and one year into VT, there were no significant differences at all ($p > 0.05$, one-way ANOVA test of homogeneity of variances) except at 6 kHz when tested on the right ear ($p = 0.022$, Table I). But at the same frequency, there was no significant difference in the left ear ($p = 0.066$). Once again, the tests of significance do not take into consideration that only hearing thresholds more than 25 dBA are clinically significant. Differences in number of enlistees with hearing loss was done with the McNemar's test, and was found to be statistically insignificant ($p = 0.238$, Table II).

The breakdown of the enlistees with abnormal audiograms is shown in Table III. Most cases of hearing loss identified are temporary and resolve on repeat audiometric assessment during the subsequent phases. There were altogether five enlistees (5.9%) identified with high tone hearing loss (HTHL) throughout all three phases; two enlistees with left-sided HTHL, two with right-sided HTHL, and one with bilateral HTHL. Of these, four cases were transient with resolution of hearing loss upon repeat assessment after BMT. There was one enlistee with right-sided HTHL who was only identified after one year of vocational training. There were altogether 20 enlistees (23.5%) with low tone hearing loss (LTHL) singled out over the three phases; two with left-sided LTHL, six with right-sided LTHL, and 12 with bilateral LTHL.

Table II. Pre-BMT and one year into VT audiogram results.

	Pre-BMT		
	Hearing loss	No hearing loss	Total
One year into VT			
Hearing loss	2	6	8
No hearing loss	12	65	77
Total	14	71	85

Chi square value = 0.467; p = 0.238; degrees of freedom = 1

Table III. Profile of hearing loss among study subjects.

Ear	Tone	Pre-BMT	Post-BMT	VT
Left	High	2	0	0
	Low	0	1	1
Right	High	1	0	1
	Low	1	3	2
Bilateral	High	1	0	0
	Low	9	4(2)	4(3)

Numbers in brackets indicate pre-existing cases of hearing loss

All but three enlistees experienced LTHL temporarily; two had persistent LTHL throughout the study and one had persistent LTHL after BMT. All three enlistees had bilateral LTHL.

DISCUSSION

There are four main causes of acquired hearing loss: acoustic trauma (both acute and chronic), infections, ototoxic drugs/chemicals and presbycusis. In the military, the concern mainly lies with exposure to noise from impulse type sounds from firearms and weapon platforms. Such impulse noises may cause acute acoustic trauma, which can in turn cause rupture of the eardrum and disruption of the organ of Corti. This often leads to abrupt hearing loss, and can possibly be prevented by wearing appropriate hearing protectors. Other defence forces have described acute acoustic trauma in conscripts, which could be prevented by using appropriate hearing protectors that are properly fitted, as well as proper and careful planning of training exercises.[5-7] Prolonged exposure to impulse noises may cause chronic acoustic trauma, which can result in sensorineural hearing loss. Studies by Sataloff et al concluded that exposure to intermittent loud noise can cause severe high frequency sensorineural hearing loss.[8] Higher frequencies are usually involved, with the 4 kHz frequency being the first to be affected. The presence of sensorineural hearing loss may also imply increased risk of noise-induced hearing deterioration.[9]

The prevalence of hearing loss in this study population at the start of BMT was 16.5%; this subsequently fell to a steady 9.4% at the end of BMT and at the end of the first year of VT. In comparison, a previous study had reported a prevalence rate of 3.67% in young Singapore adult males aged 16–23 years (the age range for this study was 18–22

years).[3] The study population had undergone a BMT package which required the use of infantry firearms and grenades, albeit for short periods of time. During firing of weapons, enlistees were encouraged to use standard issued earplugs for hearing protection. During VT, the enlistees were also exposed to other impulse noise generated from large calibre weapons, such as tanks and artillery batteries, in addition to continued exposure to impulse noise from firearms and grenades.

The prevalence of abnormal audiograms at the start of BMT was 16.5% (14 individuals). But at the post-BMT phase, the prevalence of abnormal audiograms was 9.4% (8 individuals). By the first year in VT, the number of abnormal audiograms remained the same. What could have contributed to this decrease? This was the first time that the subjects were doing the audiogram. They might not have been familiar with it and thus might not have responded correctly to the test initially. This may explain the drop from 16.5% (at pre-BMT) to 9.4% (post-BMT). Although we had requested that the subjects be given 48 hours of "loud-noise-free" period, this would be very difficult to adhere to, especially during the pre-BMT period, as the subjects were confined to their camps and could have had weekend trainings. Therefore, the effects of "temporary threshold shift" cannot be totally ruled out and could have contributed to the higher prevalence for the pre-BMT audiograms. In this study, 5.9% of the population were detected to have high frequency hearing loss, a feature which is often associated with noise-induced hearing loss. 80% (four out of five) of the enlistees with audiometric features of HTHL were suggested to be suffering from noise-induced hearing loss. Follow-up studies showed that on repeated audiograms, their hearing thresholds returned to normal.

This study also did not identify a preponderance of unilateral hearing loss over bilateral hearing loss in the study population. Analysis of hearing thresholds of the study population at the lower frequencies (0.5–4 kHz) pre- and post-BMT showed no significant differences in the average means in the two groups ($p > 0.05$, one-way ANOVA test of homogeneity of variances). However, at 6 kHz, there was significant differences in the mean hearing threshold between pre- and post-BMT audiometric scores in the right ear ($p = 0.022$). It should, however, be noted that although there were significant differences in the numerical value of the hearing thresholds, only one subject had clinically significant hearing loss, thus the actual significance of this finding is questionable. Hearing damage is cumulative, and directly related, to the duration of exposure and the noise energy levels. Although the hearing levels did not reach the accepted definition of hearing loss, a shift of hearing threshold may be significant. The shift may be temporary or permanent depending on the extent of cochlear damage. This finding of asymmetric hearing loss with a tendency towards the left ear[4,10,11] has been noted in some studies on military personnel. Hypotheses include asymmetrical exposure from rifle-firing. Analysis of the prevalence of hearing loss from the period of the start of BMT to the end of one year of VT showed that there was no significant difference between the number of enlistees with hearing loss.

Limitations of this study include the high dropout rate for the follow-up of the enlistees post-BMT, as well as other confounding factors, such as infection or ototoxicity, as an unrelated cause of hearing loss. Exposure to loud noises outside of the military context may also contribute to hearing loss in the study population. The unfamiliarity with the first audiogram by the subjects may have also contributed to the initial higher prevalence of abnormal audiogram, which dropped when the tests were repeated later. As mentioned earlier, we also cannot completely rule out the possible effect of "temporary threshold shift". We only followed-up one cohort of soldiers, hence our results may not reflect that of the whole population of enlisted soldiers.

In conclusion, there is no significant difference in the number of enlistees with hearing loss pre- and post-BMT and one year into VT in Singapore in this cohort of soldiers. It has often been assumed that conscripted army combat personnel are subjected to a noise level which can have a deleterious effect on hearing. This study serves to dispel this notion, and validates the army's efforts in promoting the safety and occupational health of our soldiers and protecting them against noise-induced hearing loss. Additionally, it would be of great value to further this study by assessing audiometric findings in the same study population at the end of their National Service. Results obtained may be invaluable in improving the hearing-conservation programmes in the SAF.

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