Associations between earplug use and hearing loss in ROK military personnel

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ABSTRACT

Introduction The easiest way to prevent noise-induced hearing loss (NIHL) is to wear earplugs. The Republic of Korea (ROK) Ministry of National Defense (MND) is supplying earplugs to prevent NIHL, but many patients still suffer from this. We speculated that earplugs would have a high NIHL rate, depending on the rate of use of earplugs, regardless of the rate of supply. Therefore, we conducted this study to investigate the relationship between the use of earplugs and hearing loss by ROK military personnel.

Methods The study used data from the Military Health Survey conducted in 2014–2015, which included 13 470 questionnaires completed by ROK military personnel. Hearing loss and earplug use were self-reported. Logistic regression analysis was used to assess associations between earplug use and hearing loss.

Results The study sample included 13 470 ROK military personnel (response rate of 71.2%) (Army, 8330 (61.8%); Navy/Marines, 2236 (16.6%); and Air Force, 2904 (21.6%). Overall, 18.8% of Korean military personnel reported that they always wore earplugs, and 2.8% reported hearing loss. In logistic regression analysis, there were significant differences in the rates of hearing loss associated with wearing earplugs sometimes (OR=1.48, 95% CI 1.07 to 2.05) and never wearing earplugs (OR=1.53, 95% CI 1.12 to 2.10). In subgroup analysis, in Air Force, non-combat branch, forward area and long-term military service personnel increased hearing loss was associated with not wearing earplugs.

Conclusion Our study confirmed that within the ROK military, there is an association between hearing loss and lack of earplug use. In the ROK MND, Army, Navy/Marines and Air Force headquarters must provide guidelines for the use of earplugs during field training to protect military personnel’s hearings and, if necessary, need to be regulated or institutionalised.

INTRODUCTION

Noise-induced hearing loss (NIHL) is a sensorineural hearing deficit that begins at the higher frequencies (3–6 kHz) and develops gradually as a result of chronic exposure to excessive sound levels.1 In addition, sudden noise of 70 dB or more can have a critical effect on the body.2 Although the hearing loss is typically symmetrical, noise from such sources as firearms or sirens may produce an asymmetrical loss.

Due to the nature of the profession, the main task is for military personnel to use guns and artillery. However, it has been reported that the noise level for a single gunshot is 75–90 dB for rifle shot and 75 dB for carbines. In addition, the M-16 rifle fire sounds are 170 dB and the artillery fire sounds are 180 dB of noise, which can cause NIHL.3 Thus, according to data provided by the Republic of Korea (ROK) Armed Forces Medical Command (AFMC), otolaryngologists in the military are estimated to treat more than 110 000 patients each year for blast-related ear injuries and/or hearing loss induced by rifle fire or artillery training.4

The easiest way to prevent way to prevent NIHL is to wear earplugs.5–7 Therefore, the ROK Army, Navy/Marines and Air Force provide military personnel with earplugs as a way of personal hearing protection and provide education to prevent NIHL.8 However, NIHL continues to arise from ROK military personnel.9

ROK military research on NIHL continues. However, unlike the case of another nation’s military attempting a multifaceted approach to the NIHL,10–12 the ROK military focused primarily on the Air Force’s hearing loss.13–15 There has been little research on the hearing of the army and navy. Therefore, we conducted this study to confirm how the use of earplugs in the Army, Navy/Marines and Air Force is related to NIHL.

METHODS

Study participants Data were obtained from the 2014–2015 Military Health Survey (MHS), which is a cross-sectional survey of military personnel that was conducted by the School of Military Medicine to investigate health determinants. The survey was designed to acquire self-reported data via a questionnaire. Raw data were obtained from the Korean Military Medical School with the dean’s approval. Because the 2014 MHS was an anonymous self-administered survey, individual responses cannot be linked to specific personnel or medical records.

To cite: Kim HJ, Oh SY, Won SY, et al. BMJ Mil Health 2021;167:398–401.
The survey was conducted every year for 5000 officers, warrant officers, non-commissioned officers (NCOs) and 5000 enlisted soldiers. The total number of survey participants during the 2 years of the study was 14 244 (response rate of 71.2%) (1914 officers and warrant officers, 3604 NCOs and 8726 enlisted soldiers). Respondents who used medical services pertaining to hearing loss over the past year were tabulated, as were those who answered questions relating to wearing earplugs.

Only respondents who answered questions identifying their sex, marital status, educational level, military type, branch, rank, working area, service classification and working time were included in the current study. The final analysis dataset included 13 470 military personnel, 94.6% of all survey respondents (1798 officers and warrant officers, 3378 NCOs and 3378 enlisted soldiers).

**Variables**

Hearing loss was the main dependent variable in the current study. The MHS investigated this via the question ‘Check all diseases you have experienced over the past year’. The analyses of hearing loss in the current study was based on respondents who checked ‘hearing loss’ in response to that prompt. The interesting variable was earplug use. The relevant question in the survey was ‘Do you wear earplugs?’. Possible answers were ‘always wear earplugs’, ‘sometimes wear earplugs’, ‘often do not wear earplugs’, ‘do not wear earplugs’ and ‘not applicable’. We distinguished between sometimes wear earplugs, often do not wear earplugs and not applicable. Not applicable was excluded from the analysis.

Several covariates were assessed, including sociodemographic, military-related and health-related characteristics. Sociodemographic characteristics included sex (male and female), marital status (married, previously married (divorced, separated or bereaved) or unmarried) and education level (high school or less, college or above). Military-related characteristics included military type (Army, Navy/Marines or Air Force), branch (combat, technique/administration or special), rank (warrant officer or commissioned officer (W1–O6), NCO (E5–E9), or enlisted soldier (E1 and E2)).

### Table 1 General characteristics of study observations (Military Health Survey 2014–2015)

| Variable | Hearing loss |        |        |        | P value |
|----------|--------------|--------|--------|--------|---------|
|          | Total (n, %) | Yes (n, %) | No (n, %) |        |         |
| Earplug use |              |        |        |        |         |
| Always    | 2528 (18.8)  | 52 (2.1) | 2476 (97.9) | 0.0353 |
| Sometimes | 4852 (36.0)  | 140 (2.9) | 4712 (97.1) |        |
| None      | 6090 (45.2)  | 186 (3.1) | 5904 (97.0) |        |
| Sex       |              |        |        |        | 0.3596  |
| Man       | 13 080 (97.1) | 370 (2.8) | 12 710 (97.2) |        |
| Woman     | 390 (2.9)    | 8 (0.2)  | 382 (98.0) |        |
| Marital status |       |        |        |        | <0.0001 |
| Married   | 1630 (12.1)  | 88 (5.4)  | 1542 (94.6) |        |
| Single (divorced, separated or bereaved) | 306 (2.3)  | 22 (7.2)  | 284 (92.8) |        |
| Never married | 11 534 (85.6) | 268 (2.3) | 11 266 (97.0) |        |
| Educational level | |        |        |        | 0.5636  |
| High school or less | 2484 (18.4) | 74 (3.0)  | 2410 (97.0) |        |
| College or more  | 10 986 (81.6) | 304 (2.8) | 10 682 (97.2) |        |
| Military type |              |        |        |        | 0.8874  |
| Army      | 8330 (61.8)  | 230 (2.8) | 8100 (97.2) |        |
| Navy and Marines | 2236 (16.6) | 66 (3.0)  | 2170 (97.1) |        |
| Air Force  | 2904 (21.6)  | 82 (2.8)  | 2822 (97.2) |        |
| Branch    |              |        |        |        | 0.3112  |
| Combat    | 8740 (64.9)  | 236 (2.7) | 8504 (97.3) |        |
| Non-combat | 4730 (35.1)  | 142 (3.0) | 4588 (97.0) |        |
| Rank      |              |        |        |        | 0.0023  |
| Warrant officer and commissioned officer (W1–O6) | 1798 (13.4)  | 58 (3.2)  | 1740 (96.8) |        |
| Non-commissioned officer (E5–E9) | 3378 (25.1)  | 118 (3.5) | 3260 (96.5) |        |
| Enlisted soldier (E3 and E4) | 3958 (29.4) | 110 (2.8) | 3848 (97.2) |        |
| Enlisted soldier (E1 and E2) | 4336 (32.2)  | 92 (2.1)  | 4244 (97.9) |        |
| Working area |            |        |        |        | 0.3557  |
| Forward area | 8922 (66.2) | 242 (2.7) | 8680 (97.3) |        |
| Rear area  | 4548 (33.8)  | 136 (3.0) | 4412 (97.0) |        |
| Service classification | |        |        |        | <0.0001 |
| Long-term military service | 2922 (21.7) | 150 (5.1) | 2772 (94.9) |        |
| Short-term military service | 10 548 (78.3) | 228 (2.2) | 10 320 (97.8) |        |
| Working time (hour/week) | |        |        |        | 0.4297  |
| ≤48       | 6684 (49.6)  | 180 (2.7) | 6504 (97.3) |        |
| ≥49       | 6786 (50.4)  | 198 (2.9) | 6588 (97.1) |        |
| Total     | 13 470 (100.0) | 378 (2.8) | 13 092 (97.2) |        |
The sample included 13,470 military personnel (Army, 8,330 (61.8%); Navy/Marines, 2,236 (16.6%); and Air Force, 2,904 (21.6%)). Overall, 2.8% of military personnel reported that they had experienced hearing loss. Most military personnel either sometimes wore earplugs or never wore earplugs. Of the total 13,470 respondents, 2,528 (18.8%) reported that they always wore earplugs; 4,852 (36.0%) reported that they sometimes wore earplugs and those who reported sometimes wearing earplugs or never wore earplugs. Of the total respondents, 2,528 (18.8%) reported that they always wore earplugs; 4,852 (36.0%) reported that they sometimes wore earplugs and those who reported sometimes wearing earplugs or never wore earplugs. Of the total 13,470 respondents, 2,528 (18.8%) reported that they always wore earplugs; 4,852 (36.0%) reported that they sometimes wore earplugs and those who reported sometimes wearing earplugs or never wore earplugs. Of the total 13,470 respondents, 2,528 (18.8%) reported that they always wore earplugs; 4,852 (36.0%) reported that they sometimes wore earplugs and those who reported sometimes wearing earplugs or never wore earplugs.

### Statistical analysis

The χ² test and logistic regression analysis were used to analyse associations between earplug use and hearing loss. The χ² test was used to investigate the significance of differences in hearing loss, depending on earplug use. Logistic regression analysis was used to determine ORs and 95% CIs. Subgroup analysis of earplug use was performed based on hearing loss, sex, marital status, educational level, military type, branch, working area and service classification. Statistical analyses were performed using SAS software V9.4. A p value of <0.05 was deemed to indicate statistical significance.

### RESULTS

The sample included 13,470 military personnel (Army, 8,330 (61.8%); Navy/Marines, 2,236 (16.6%); and Air Force, 2,904 (21.6%)). Overall, 2.8% of military personnel reported that they had experienced hearing loss. Most military personnel either sometimes wore earplugs or never wore earplugs. Of the total 13,470 respondents, 2,528 (18.8%) reported that they always wore earplugs; 4,852 (36.0%) reported that they sometimes wore earplugs and those who reported sometimes wearing earplugs or never wore earplugs. Of the total 13,470 respondents, 2,528 (18.8%) reported that they always wore earplugs; 4,852 (36.0%) reported that they sometimes wore earplugs and those who reported sometimes wearing earplugs or never wore earplugs.

### Table 2  Factors associated with hearing loss and whether to use earplugs (Military Health Survey 2014–2015)

| Variables                          | Hearing loss | Adjusted OR (95% CI) | P value |
|------------------------------------|--------------|----------------------|---------|
| Earplug use                        |              |                      |         |
| Always                             | 1.00         |                      |         |
| Sometimes                          | 1.48 (1.07 to 2.05) | 0.0185             |         |
| None                               | 1.53 (1.12 to 2.10) | 0.0081             |         |
| Sex                                |              |                      |         |
| Man                                | 1.00         |                      |         |
| Woman                              | 1.54 (0.74 to 3.24) | 0.2516             |         |
| Marital status                     |              |                      |         |
| Married                            | 1.00         |                      |         |
| Single (divorced, separated or bereaved) | 1.38 (0.85 to 2.26) | 0.1963             |         |
| Never married                      | 0.69 (0.47 to 0.99) | 0.0462             |         |
| Educational level                  |              |                      |         |
| High school or less                | 0.92 (0.70 to 1.20) | 0.5262             |         |
| College or more                    | 1.00         |                      |         |
| Military type                      |              |                      |         |
| Army                               | 1.16 (0.82 to 1.64) | 0.409              |         |
| Navy and Marines                   | 1.06 (0.74 to 1.52) | 0.7414             |         |
| Air Force                          | 1.00         |                      |         |
| Branch                             |              |                      |         |
| Combat                             | 1.16 (0.90 to 1.48) | 0.2489             |         |
| Non-combat                         | 1.00         |                      |         |
| Rank                               |              |                      |         |
| Warrant officer and commissioned officer (W1–O6) | 1.00         |                      |         |
| Non-commissioned officer (E5–E9)   | 1.14 (0.80 to 1.61) | 0.4675             |         |
| Enlisted soldier (E3 and E4)       | 2.58 (1.57 to 4.25) | 0.0002             |         |
| Enlisted soldier (E1 and E2)       | 1.92 (1.15 to 3.18) | 0.0123             |         |
| Working area                       |              |                      |         |
| Forward area                       | 1.06 (0.80 to 1.40) | 0.6752             |         |
| Rear area                          | 1.00         |                      |         |
| Service classification             |              |                      |         |
| Long-term military service         | 1.00         |                      |         |
| Short-term military service        | 0.27 (0.17 to 0.44) | <0.0001            |         |
| Working time (hour/week)           |              |                      |         |
| ≤48                                | 1.03 (0.83 to 1.28) | 0.7955             |         |
| ≥49                                | 1.00         |                      |         |

### Table 3  Factors of hearing loss depending on whether to use earplugs (Military Health Survey 2014–2015)

| Variables                          | Always use earplugs | Adjusted OR (95% CI) | P value |
|------------------------------------|---------------------|----------------------|---------|
| Sex                                | Man                 | 1.44 (1.04 to 1.99) | 1.51 (1.10 to 2.07) |
| Woman                              | 1.00                |                      |         |
| Marital status                     | Married             | 1.01 (0.51 to 2.00) | 1.81 (0.98 to 3.32) |
| Single (divorced, separated or bereaved) | 2.04 (0.43 to 9.64) | 0.83 (0.21 to 3.28) |
| Never married                      | 1.68 (1.14 to 2.48) | 1.55 (1.05 to 2.28) |
| Educational level                  | High school or less | 1.03 (0.47 to 2.26) | 2.00 (0.99 to 4.03) |
| College or more                    | 1.58 (1.10 to 2.26) | 1.40 (0.98 to 2.00) |
| Military type                      | Army                | 1.33 (0.89 to 1.98) | 1.32 (0.89 to 1.95) |
| Navy and Marines                   | 1.43 (0.70 to 2.90) | 0.80 (0.38 to 1.65) |
| Air Force                          | 1.77 (0.70 to 4.47) | 3.41 (1.44 to 8.06) |
| Branch                             | Combat              | 1.42 (0.96 to 2.09) | 1.39 (0.95 to 2.03) |
| Non-combat                         | 1.59 (0.87 to 2.91) | 1.80 (1.01 to 3.21) |
| Working area                       | Forward area        | 1.52 (1.01 to 2.30) | 1.68 (1.13 to 2.50) |
| Rear area                          | 1.46 (0.86 to 2.48) | 1.36 (0.81 to 2.28) |
| Service classification             | Long-term military service | 1.43 (0.85 to 2.43) | 1.88 (1.15 to 3.08) |
| Short-term military service        | 1.49 (0.98 to 2.26) | 1.31 (0.87 to 1.98) |
likely to have experienced hearing loss (OR=1.88, 95% CI 1.15 to 3.08).

DISCUSSION
This study can be used as a basis for demonstrating the effects of wearing earplugs during training. ROK Defense, Army, Navy/Marines and Air Force Command provide earplugs to protect the military personnel’s hearing. However, in our analysis, 81.2% of military personnel responded they never use or sometimes use earplugs. Hearing loss was most likely in military personnel who never use earplugs or sometimes use earplugs. This suggests that the continued use of earplugs is important.

We suggest the following points. First, efforts to protect military personnel’s hearings must be continued. Ministry of National Defense should continue to provide earplugs to military personnel so that they are not exposed to hearing loss. Second, military personnel should be educated on the importance of continued use of earplugs. Our study found that the group which occasionally wears earplugs was 1.48 times more likely to have a hearing loss than the group which always uses earplugs. The group which never uses earplugs was 1.53 times more likely to have a hearing loss than the group which always uses earplugs. This suggests that if you do not continue to use earplugs, your exposure to hearing loss is similar to the never-use group. Therefore, earplugs should always be worn to protect the military personnel’s hearing. Finally, it is necessary to analyse the cause of the poor use of earplugs. Only 18.8% of military personnel in our study said they always used earplugs. It is necessary to examine when the use of earplugs does cause discomfort or dissatisfaction for military personnel, and if evidence is found, efforts will be needed to improve them.

The present study had some limitations. First, MHS asked if military personnel had hearing loss and if they wore earplugs in general. Because the current study utilised self-reported data, recall bias can occur at this point. Second, if there was any dissatisfaction with the earplugs supplied, self-reported data may reflect a tendency to under-report usage. Third, because this study is a cross-sectional study, there was no capacity to thoroughly investigate causal relationships between hearing loss and earplug use in the ROK military. A randomised controlled trial is needed to investigate such relationships, but notably, such trials involving military personnel are very limited in the ROK military. Therefore, it is necessary to accumulate long-term data such as those derived from military defence cohorts, to analyse the phenomena of interest. Fourth, it would have been better if the study analysed the effect of wearing earplugs on the severity of hearing loss. However, due to the limitation of the data, the analysis according to the severity could not be performed. Lastly, the sample population consisted entirely of ROK military personnel so the results of the study may not be readily generalisable to other groups.

Despite the aforementioned limitations, the present study had several strengths. The data used were sourced from the largest survey ever conducted by the ROK AFMC, which was undertaken to investigate health behaviours in military personnel and facilitate the calculation of health-related statistics required for health business planning and evaluation. That survey was administered to more than 13 000 military personnel and incorporated the selection of representative samples with regard to distributions of class, health status and region in the ROK Army, Navy/Marines and Air Force. Therefore, the data were derived from the largest healthcare-related survey conducted in military personnel. Another strength of the study is that as well as ROK Air Force personnel, it incorporated ROK Army and ROK Navy/Marines personnel. Hitherto, studies investigating hearing loss in the ROK military have mainly focused on the Air Force. To the best of our knowledge, this is the first study to investigate hearing loss and earplug use in the ROK Army, Navy/Marines and Air Force.

CONCLUSION
Our study confirmed that within the ROK military, there is an association between hearing loss and lack of earplug use. In the ROK Defense, Army, Navy/Marines and Air Force headquarters, consideration of mandatory equipment wearing and modernisation of equipment is necessary for the protection of military personnel’s hearing.

Contributors
HWJK: conceptualisation, study design, data collection, overview, literature review, formal analysis and write-up. SYW: methodology and review. S1W: data collection, analysis and review. HAJK: study design, data collection and review. TKK and BCK: data collection and review. SYW: review and write-up. E-CP: supervision.

Funding
The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests
None declared.

Patient consent for publication
Not required.

Provenance and peer review
Not commissioned; internally peer reviewed.

Data availability statement
Data are available upon reasonable request.

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