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Occupational Hearing Loss in Korea

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In this article, current status of noise exposure in workplaces, trend of workers with noise-induced hearing loss (NIHL), and prevalence of NIHL in workers by industry and job category in Korea were reviewed. In addition, trends of research on the audiological effects such as hearing loss from noise and occupational hearing loss from non-noise in Korea were addressed through reports in industrial audiology. Though noise exposure level has improved, noise still shows the highest rate of cases exceeding exposure limit among workplace hazards. NIHL is the most common occupational disease except work-related disease such as musculoskeletal disorders and cerebrovascular diseases, and NIHL prevalence is thought to be much higher than reported in official publications. Noise affecting hearing comes from various sources such as workplaces, military settings, areas with exposure to high noise, and specific noise sources. There is also occupational hearing loss by non-noise including chemicals such as organic solvents and heavy metals, barotrauma, and trauma due to welding spark. Noise affects daily life through audiological effects such as hearing loss and tinnitus, non-audiological physical effects (e.g., cardiovascular), and psychosocial and behavioral effects. Development of systematic and comprehensive hearing conservation programs for lowering the noise level in workplaces and preventing the NIHL, and preparation of technological, administrative system for its settlement at workplace are urgently needed.

Key Words: Occupational Hearing Loss; Noise-Induced Hearing Loss; Korea

INTRODUCTION

Workers may experience typical noise-induced hearing loss (NIHL) and other various problems of occupational hearing loss. Occupational hearing loss is a hearing loss from environment to which workers are exposed, and severity may range from mild to even total deafness. Occupational hearing loss can be of any types, i.e. conductive, sensorineural, or a combination. Eardrum perforation from head injury, explosion, sharp objects, metal scrap or metal spark is an example of occupational conductive hearing loss; NIHL due to persistent exposure to noise, and hearing loss due to perilymphatic fistula, acoustic trauma, ototoxic substances, and inner ear and round window membrane rupture from trauma or barotrauma are examples of sensorineural hearing loss. Occupational hearing loss is usually bilateral, through occasionally unilateral. By causes, NIHL is the most common, and ototoxic hearing loss due mainly to various neurotoxic industrial chemicals, acoustic traumatic hearing loss, hearing loss due to abnormal atmospheric pressure, traumatic hearing loss, and sudden hearing loss, which is assumed to be induced by noise in relation to exposure noise level and time of occurrence, are also observed. Currently in Korea, hearing loss which would be recognized for occupational accident compensation is 1) acute accidental hearing loss from trauma, 2) acute acoustic traumatic hearing loss from unexpected exposure to loud noise, or 3) NIHL from long-term exposure to noise.

Noise is the primary cause of occupational hearing loss. Workplace noise is inevitably generated in various operation processes, and causes direct harms such as accident or lowered operation efficiency as well as NIHL. Workplace noise is also reported to influence the development of cardiovascular diseases and hypertension in addition to hearing defect. High noise level is a causal factor for severe stress, and impacts health and daily life, e.g. through performance disorders, sleep disorders, and conversation interference. There have been many reports on the physical, emotional, behavioral, and social effects of hearing defects from noise.

Research in industrial audiology in Korea include studies on prevalence rate of NIHL by occupational epidemiological investigation or Workers' Health Examination data, noise-related Workers' Health Examination system and standard, influencing factors for hearing of workers exposed to noise, the effect of noise on non-ear disease (particularly the relation between noise exposure and blood pressure), the effect of hazards other than noise on hearing, influencing factors for hearing test, and follow-up measures and workers' awareness for noise.

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In this article, current status of noise exposure in workplaces, trend of workers with NIHL and workers with a suspicious case of NIHL (D_1) by the periodic Special Health Examination, and prevalence of NIHL in epidemiological investigations or research on diverse industry categories and job categories in Korea will be reviewed. In addition, this article will address the recent research trends and major issues in industrial audiology for audiological effects such as hearing loss and hearing disability from hazards including noise in Korean workers.

MATERIALS AND METHODS

Current status of noise exposure was examined through recent (2002-2005) data from working environment monitoring and data from working environment inspection by industry category. Current status of NIHL was examined through annual data on workers with a suspicious case of NIHL (D_1) by the periodic Special Health Examination for noise according to the Occupational Safety and Health (OSH) Act and data of NIHL cases compensated by the Industrial Accident Compensation Insurance (IACI) Act. The data were compared with the total number of occupational diseases and the distribution of workers with occupational disease compensated by IACI. In addition, prevalence of NIHL or hearing loss on researches by industry category/job category are presented.

Literature review for occupational hearing loss in Korea was done by using 'noise', 'hearing', and 'hearing loss' as key words in relevant journals such as the Korean Journal of Occupational and Environmental Medicine, Korean Journal of Preventive Medicine, Korean Journal of Otorhinolaryngology-Head and Neck Surgery, Korean Journal of Audiology, Korean Journal of Aerospace and Environmental Medicine, and Maritime Medicine. Search results were divided into two categories: the effect of noise on hearing and occupational hearing loss caused by non-noise factors. For the effect of noise on hearing, effects of military noise, and other specific noise sources on hearing, and effect of noise on ear symptoms other than hearing loss are discussed. Research on criteria for NIHL; risk factors for NIHL; health effect of noise on non-ear disease, such as physiological or psychosocial effects; and awareness and follow-up measures for noise were excluded from discussion.

RESULTS

Current status of noise exposure

The noise exposure limit in Korea is 8-hr time weighted average (TWA) noise intensity of 90 dBA, and "5-dB exchange rate", by which exposure time may be halved for each 5-dB increase in noise level is applied. In addition, it is stipulated that noise should not exceed 115 dBA.

Noise exposure limit is exceeded in more than 90% of all workplaces of which any hazard exceeds exposure limit in Korea, e.g., about 92.5% in the second half of 2006 (1). The Work Environment Survey performed in 1999 demonstrated that 53.3% of a total 52,070 companies had noise-generating processes, and 12.1% of workers were working at those processes (2).

Recent Working Environment Monitoring from 2002 to 2005 for noise in the working environment showed little change in rate of exceeding exposure limit of noise: proportions of workplaces exceeding the limit and cases exceeding the limit were 23.9% and 22.9%, respectively, in the first half of 2002, and 28.7% and 19.3%, respectively, in the second half of 2005 (Fig. 1). Noise assessment data from those 4 yr revealed that mean noise level was 84-86 dBA (Fig. 2), and the proportion of cases with noise from 80-90 dBA were 64.6%, cases exceeding 100 dBA were 1.3%, and cases lower than 80 dBA were 11.1% (3).

Although sound pressure level reported by the industry category varies depending on authors, the frequency range reported recently at noise-generating processes of workplaces in Korea by the industry category indicates some improvement of noise-related working environment. The 1985 noise assessment study conducted in the manufacturing industry in Busan reported that noise exceeded 90 dBA in shipbuilding, steel rolling, automobile manufacturing, and textile product manufacturing, and exceeded 85 dBA in foundry, metal products manufacturing, aquatic product processing, and rubber product manufactur-

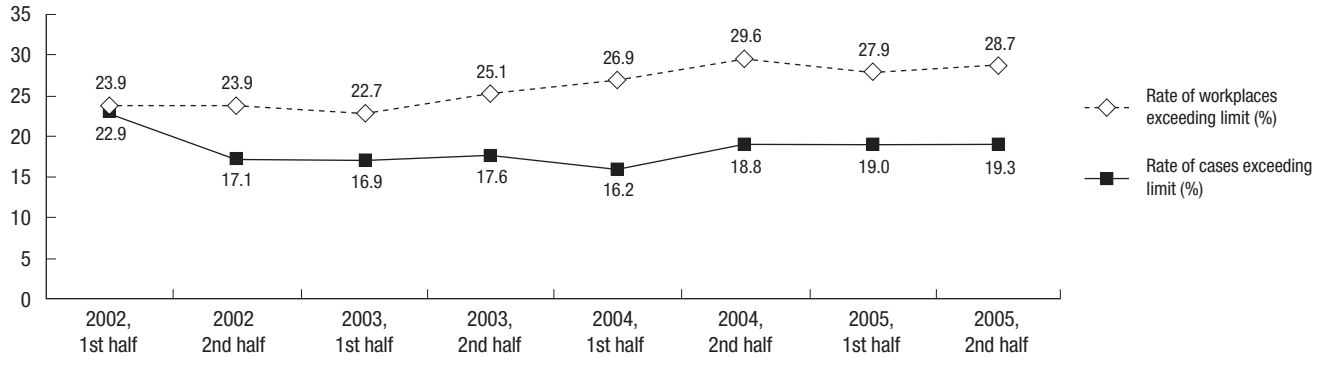

Fig. 1. Trend of the rate of workplaces exceeding the noise exposure limit and the rate of cases exceeding the noise exposure limit.

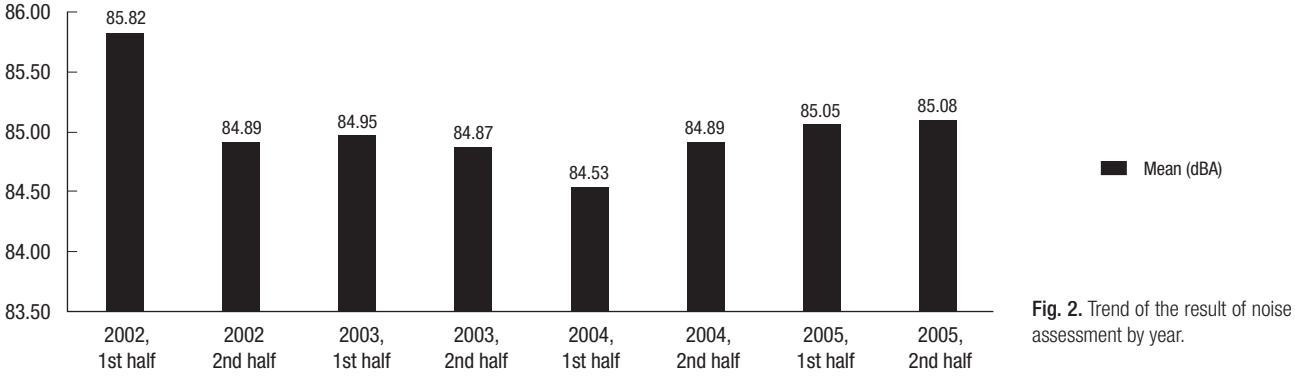

Fig. 2. Trend of the result of noise assessment by year.

ing. Noise exceeded the exposure limit in 42% of the investigated processes (4). Among 22,384 workplaces monitored for working environment during the second half of 2001, the 90 dBA noise exposure limit was exceeded in 5,785 workplaces (25.8%). Analyses for noise intensity, workplace scale, area, and number of processes exceeding the exposure limit in these workplaces by the industry category revealed that textile manufacturing and fabricated metal products manufacturing industries were the most vulnerable to noise. Results also showed that regarding workplace scale, small-sized industries employing less than 50 workers were the most vulnerable to noise exposures; regarding area, Gyeongsang-do province was the most vulnerable region. Furthermore, textile manufacturing and primary metal industries had the highest number of exposure operations exceeding the noise exposure limit (5).

Rate of processes with noise exceeding exposure limit in the automobile industry was 19.7% during 2000-2001, which was lower than 24.9% during 1995-1997 (6), but the nationwide noise assessment in iron and steel foundry operations in 2001 reported a mean of 87.4 dBA (close to exposure limit) (7). An assessment of noise exposure by job and dosimeter parameter in automobile press factories revealed that the levels exceeded 85 dBA, recommended by the US National Institute for Occupational Safety and Health (NIOSH) in all leaders and forklift drivers and in 83.3%, 97.4% and 91.7% of press operators, pallette men and crane operators, respectively (8).

Considering that workplace noise levels may decrease in the future due to improving mechanical engineering, NIHL might remain as the most serious occupational disease problem in Korea because of its long latency and aging of workers.

Prevalence of NIHL

NIHL accounts for the highest portion of workers with occupational disease detected by periodic Special Health Examination which has been performed in accordance with the OSH Act, and more than 10% of examinees are determined as case of abnormal findings (C) (9). In addition, NIHL is the most common occupational disease among diseases compensated by the IACI Act, except work-related disease such as musculoskeletal disorders and cerebrocardiovascular diseases.

Table 1. Trend of the number of suspicious cases of NIHL (D_1) and the number of NIHL occupational disease cases

Year	Number of suspicious cases of occupational diseases	Number of suspious cases of NIHL(D_1) (%)	Number of compensated occupational disease cases (%)	Number of NIHL cases (%)
1991	7,187	3,990 (55.5)	1,537	178 (11.6)
1992	5,937	3,345 (56.3)	1,328	311 (23.4)
1993	4,327	2,421 (56.0)	1,413	257 (18.2)
1994	3,084	1,746 (56.6)	918	212 (23.1)
1995	3,224	1,943 (60.3)	1,120	159 (14.2)
1996	2,884	1,736 (60.2)	1,529	163 (10.7)
1997	2,428	1,389 (57.2)	1,424	284 (19.9)
1998	1,928	849 (44.0)	1,288	232 (18.0)
1999	1,780	1,056 (59.3)	1,897	204 (10.8)
2000	2,191	1,368 (69.3)	2,937	251 (10.2)
2001	1,919	1,330 (69.3)	4,396	287 (6.5)
2002	2,419	2,000 (82.7)	4,190	219 (5.2)
2003	2,736	2,235 (81.7)	7,740	314 (4.1)
2004	2,634	2,202 (83.6)	7,895	266 (3.4)
2005	2,380	2,074 (87.1)	6,400	302 (4.7)
2006	4,028	3,726 (92.5)	10,235	272 (2.7)
2007	4,825	4,483 (92.9)	11,472	237 (2.1)

Source: Annual Reports of Workers' Health Examination, by the Korean Ministry of Labor; Statisitics on occupational injuries and diseases by the Korean Ministry of Labor and KOSHA.

The number of workers with suspicious cases of NIHL in Workers' Health Examination (General, Special, Pneumoconiosis, and others) reached a peak in 1991 with 3,990 and decreased to 849 in 1998, but it still causes 80-90% of suspicious case of occupational disease and has increased from the low in 1998 to between 2,000-4,000 every year since 2002. Among compensated occupational diseases by the IACI Act, NIHL was responsible for 10-20% of cases every year until 2000 and decrease to about 5% since 2000 due to increasing work-related diseases such as musculoskeletal disorders. In 2007, 4,483 workers were reported as having suspicious cases of NIHL (D_1) comprising 92.9% of total workers with suspicious cases of occupational disease; hearing loss compensated by the IACI Act was 237, comprising 2.1% of compensated occupational disease (Table 1).

However, prevalence of NIHL is thought to be higher and more

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Table 2. Reports on prevalence of NIHL in workers exposed to noise

Authors	No. of subjects	Criteria	Prevalence (%)
Yoon JS et al. (1966) (10)	4,259 miners	≥40 dB at 4 kHz	6.85%
Kile BD and Lee SH (1970) (11)	306 workers exposed to noise in 75 manufacturing companies in the Yeongdeungpo region	≥40 dB at 4 kHz	34.6% (male 30.7%, female 42.6%)
Park KH and Maeng KH (1971) (12)	360 workers in 17 workplaces in 8 industry categories nationwide	Rate of hearing loss by early loss index (ELI)	Mean rate of hearing loss about 40%; about 80% in miners
Park YS (1977) (13)	754 workers in departments with noise over 90 dBA in the Jeonbuk area	Criteria for hearing loss: less than 40 dB at 4 kHz, excluding Age-Specific Presbycusis Value (ASPV)	15.9% in workers with work duration less than 5 yr; 26.9% in workers with work duration of 5-9 yr; 38.2% in workers with work duration more than 10 yr
Moon YH (1977) (14)	1,970 workers exposed to noise higher than 90 dB(A) in the Seoul-Incheon region	Hearing loss ≥31 dB by mean of 6 frequency method ELI	Right ear 8%, left ear 10% Right ear 29%, left ear 31%
Kim JY et al. (1982) (15)	2,963 workers working at 12 workplaces in rubber, textile, or steel industries with noise higher than 90 dB(A) in the Busan region	Hearing loss by mean of 6 frequency method	≥21 dB: 5.43%, ≥31 dB: 2.53%, ≥41 dB: 0.80%
Lee JT (1988) (16)	3,104 workers at 84 workplaces in 9 manufacturing industries in Busan region	Hearing loss ≥41 dB by the mean of 6 frequency method	Total: 2.9% Shipbuilding and repairing, automobile manufacturing: 5.2%
Cho YC et al. (1988) (17)	1,474 workers in 6 industry categories in Chungnam and Chungbuk	≥45 dB at 4 kHz	8.1%
Lee CU et al. (1988) (18)	3,104 workers in 84 manufacturing factories in 9 industry categories	≥50 dB at 4 kHz at primary examination	7.3%
Lee CU et al. (1988) (18)	3,104 workers in 84 manufacturing factories in 9 industry categories	Hearing loss ≥41 dB by the mean of 6 frequency method at secondary audiometry	2.9%
Lee YH (1989) (19)	3-year follow-up of workers presenting hearing loss more than 50 dB at 4 kHz in factories in the Ulsan region	Hearing loss ≥41 dB by the mean of 6 frequency method	In 1986, 0.4% of total workers; increased to 0.8% in 1987 and 1.5% in 1989
Kim SC (1991) (20)	116 workers presenting hearing loss more than 40 dB at 4 kHz at primary examination, among 6,027 workers at an automobile manufacturer	Hearing loss >25 dB by the mean of 4 frequency method	109 workers (94%)-hearing loss prevalence among 6,027 total workers was 1.81%
Lim HS et al. (1992) (21)	100 steel plant workers	Criteria of year 1985	2.2%

serious than in official publications, though gender, industry category, standard for evaluating the hearing (frequency, method for evaluating threshold-weighted value and hearing loss threshold limit value) have varied. Rate of threshold shift in high frequency region (4 kHz) higher than 40 dB has been reported to be from around 10% up to 34.6%. Reported prevalence of NIHL ranges from 0.8% by Kim et al. (15) to 2.9% by Lee (16) on the basis of 40 dB by the mean of 6 frequency method, which is the level for compensation by the IACI Act (Table 2).

NIHL is diagnosed and controlled mainly by Workers' Health Examination in Korea. The periodic Special Health Examination for noise under the OSH Act includes 1) job history and exposure history examination, 2) disease history examination, 3) subjective symptom examination, 4) and clinical examination and pure tone air conduction audiometry (2,000, 3,000, 4,000 Hz at both ears) as primary examinations. In any case of hearing loss of more than 30 dB at 2,000 Hz or 40 dB at 3,000 Hz or 40 dB at 4,000 Hz detected by the essential pure tone air conduction audiometry, pure tone audiometry (air conduction and bone conduction of both ears; 500, 1,000, 2,000, 3,000 4,000, 6,000 Hz pure tone audiometry) and middle-ear test (tympanometry) shall be carried out. With Workers' Health Examination, workers are determined as having suspicious cases of NIHL (D_1) when 1) hearing loss of more than 50 dB in 4000 Hz high frequency region is recognized by air conduction pure tone audiometry, and mean hearing loss of more than 30 dB by the mean of 3 frequency method (calculated by [a+b+c]/3, where 500[a], 1000[b], 2000[c]), and 2) hearing loss is estimated to result from noise exposure by job history. According to results from Workers' Health Examination, performance suitability is evaluated, and follow-up measures are performed such as health consulting, personal protective equipment, follow-up examination, treatment while working, working hours reduction, job transfer, work prohibition or limitation, and guide for referral for confirming diagnosis of occupational disease.

NIHL is compensated as work-related disease by the IACI Act if the following criteria are met: workers who have been working or have a history of working in workplaces with continuous noise ≥85 dBA for ≥3 yr; more than 40 dB sensorineural hearing loss by the mean of 6 frequency method in one ear; no obvious lesions in eardrum or middle ear; no obvious difference between air conduction hearing threshold and bone conduction hearing threshold on pure-tone audiometry; more hearing impairment in high frequency than low frequency region; and hearing loss

which is not due to labyrinthitis, drug addiction, febril disease, Meniere's syndrome, syphilis, head trauma, sudden hearing loss, genetic hearing loss, familial hearing loss, senile deafness, or accidental blasts.

Effect of noise on hearing

Effect of military noise on the development of NIHL

There are many studies in other countries noise-exposure during shooting and firing drills in the military. Literature review demonstrates that the characteristics of military history-related hearing loss are: acoustic traumatic hearing loss, early hearing loss in high frequency region (especially 6-8 kHz), hearing asymmetry, sensorineural hearing loss affecting cochlea and central auditory nerve track. Evaluation of mean hearing threshold reveals initial mild hearing loss, close association with military service branch, and little effectiveness of hearing protection. In addition, it is frequently accompanied by tinnitus.

Studies related to the audiological effect of military noise have addressed mainly the severity of hearing loss and prevalence of NIHL. Ko et al. (22) reported that 23% of otologically normal air force soldiers working at runways were C_5-dip type. In a study of navy soldiers, Oh et al. (23) reported that 24.8% of soldiers in artillery jobs and 18.0% of soldiers in boiler jobs showed hearing loss of more than 30 dB by four division method. Among officers on active service who were piloting military aircraft, 36.9% and 11.5% complained of noise-induced hearing defect and tinnitus, respectively (24). Significant difference in hearing loss was observed among male college students by military service experience and shooting and firing noise exposure experience (25). 10.7% of expectant employees of a company who completed military service showed C_5-dip findings, which is an early sign of NIHL (26). Regarding military service history, total flying hours was closely related to prevalence of NIHL or hearing threshold level in air force pilots (24, 27, 28), and hearing loss rate was increased together with age and service duration. Considering the audiological effect on workers exposed to noise during their military experience, it was found that noise at the current job is the first culprit of NIHL, followed by the noise exposure experienced in the military (29).

Effect of other specific noise sources on hearing

There has been a study on female communication workers wearing headsets (30), a study on high school students using personal cassette players (31), one on the effect of mobile phone use on hearing (32), and one on employees working for a metropolitan subway corporation investigating the prevalence of NIHL and related risk factors (33). Exposure level of headset noise exceeds permissible exposure limit; hearing threshold differed significantly according to volume level and hours per day in using a personal cassette player; effect of mobile phone use on hearing was low, but the relationship between mobile phone use and hearing thresholds might differ by frequency and gender; and prevalence of NIHL was lower in employees working at Seoul metropolitan subway cooperation than in workers examined by Workers' Health Examination, but some processes in the vehicle department might cause impaired hearing.

Effect of noise on ear symptoms other than hearing loss

In a study of manufacturing workers (noise exposure group) and design workers (control group) at shipyard, tinnitus prevalence was 24.3% and 3.6%, respectively (34). In a study of workers in small and medium shipbuilding and repairing companies, hearing thresholds at all frequencies except for 500 Hz, proportion of workers with hearing loss, and severity of hearing loss were found to be significantly higher in workers with tinnitus compared with workers without tinnitus, and past history of ear disease, past exposure to strong impact noise during military service, and noise exposure at current job significantly affected tinnitus development (35). In a study of residents near US military airbases in Pyeongtaek, Korea, odds ratios of complaint of tinnitus symptoms between aircraft noise-exposed and control groups was 2.06 (95% CI: 1.09-3.88) and 1.97 (95% CI: 1.17-3.30) in males and females, respectively, and prevalence of tinnitus in the exposed group was higher than that by occupational noise (36). However, comparison between workers with NIHL (study group) and a normal population (control group) did not reveal a significant vestibular function impairment from chronic noise exposure (37).

Occupational hearing loss from non-noise

There have been only a few studies: a report of progressive hearing loss in workers exposed to carbon disulfide (38); a study on correlation between blood lead level and hearing impairment for investigating hearing impairment from lead exposure (39); a study on the effect of exposure to mixed organic solvents on hearing in video tape manufacturing workers (40); a study on the effect of exposure to organic solvents on occupational hearing loss in noise exposure group and group concomitantly exposed to noise and organic solvents in metal products manufacturing company workers (41); and a study comparing the hearing loss by category according to characteristics of exposure to noise and chemicals such as heavy metals and organic solvents (42). Mean hearing threshold was higher in the mixed organic solvent-exposed group than in the non-exposed group, and hearing threshold was higher in the subgroup with simultaneous exposure to organic solvent and noise than in the noise-exposed group at frequencies higher than 4,000 Hz. Hearing threshold significantly differed by job category such as ship fitter, welder, and painter with regard to exposure to noise and chemicals such as organic solvent and heavy metal.

A recent increase in occupational diving has led to an increase in incidence of disability from these activities. Barotrauma, a

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somatic tissue injury in otorhinolaryngological area such as middle ear and sinus due to change of pressure, is the most frequently observed medical problem, though less serious. Several studies have been carried out in Korea: a study of professional female sea-water divers showed significantly increased hearing impairment compared with a normal population, especially in high frequencies, and close correlations between hearing impairment and work duration and working depth (43). There was also an animal study, which investigated the development of barotrauma and change in middle ear barotrauma over time in the middle ear of guinea pigs after simulated diving (44). For other cases of traumatic hearing loss, eardrum perforation and chronic otitis media due to welding spark were reported in welders (45).

DISCUSSION

Current status of noise exposure in workplaces and trend of NIHL cases in Korea were reviewed through data from the Working Environment Monitoring and from the periodic Special Health Examination for noise and compensated cases according to the IACI Act. In addition, industrial audiological studies published in various scientific journals in Korea revealed prevalence of NIHL, effect of military noise exposure other than occupational noise in noise-exposed workers, effect of specific noise sources on hearing, effect of noise on ear symptoms other than hearing loss, and effect of non-noise on occupational hearing loss and hearing.

In Korea, countermeasures for impact noise exposure from shooting and firing during military service are lacking. Although military noise exposure greatly influences the development of NIHL at workplaces, there are no criteria for it, resulting in discrimination in labor market and trouble in health management. In Korea, workers generally have experience in military duty for a long period at a young age prior to beginning their profession; a considerable number of them have limited participation in shooting drills, and soldiers in specific military service branches - such as artillery, panzer, and air force and navy soldiers - are exposed to impact noise at all times. Many studies have reported that the noise level of these military exposures is quite high on average, with higher maximum exposure levels. Therefore, for early diagnosis, treatment, compensation and prevention of hearing loss of noise-exposed workers in view of hearing care, the scope should be extended to include the issue of military noise exposure.

Effects of specific noise sources other than general workplace noise or noise in jobs in non-manufacturing industries on hearing have not been studied until recently. In this field, the effect on hearing is not conspicuous but exposure noise level is high enough to affect hearing, and therefore needs continuous attention.

Tinnitus often accompanies hearing loss and may induce physical disability together with hearing loss, and is likely to be a symptom signaling possible future disability in workers exposed to workplace noise, among others. Tinnitus caused by noise exposure is drawing less attention than NIHL, but the possibility of tinnitus development needs to be taken into account in hearing conservation programs because the high association reported between noise exposure and tinnitus.

Effects by hazards other than noise on occupational hearing loss and hearing are not being studied vigorously. Hearing losses from exposure to industrial chemicals at workplaces are diverse, complex, and controversial. Recently, audiological effects were examined in human exposed to chemicals as well as in animal. Chemicals may replace noise as a major factor for hearing loss in this time of working environment change from heavy industry with noisy workplaces to computer-based and high-technical industry. Additional care is needed in current hearing screening programs, as elderly workers are particularly more susceptible to ototoxic chemicals. More focus should be on industrial chemicals such as those affecting the central nervous system, because of their theoretically or experimentally possible effects on the auditory system, reports of their interaction with noise or effect on hearing, scale of workers who are exposed to noise and chemicals, and various chemicals being used in workplaces. Research in this area is greatly needed, especially considering the present lack of standards for mixed exposure to physical factors and chemicals.

As seen above, studies on noise among workplace hazards are continuously carried out in Korea. However, regarding the industrial audiological research trends in other countries, the scope of studies in Korea should be extended to include: occupational hearing loss other than NIHL (audiological health consequences from vibration, organic solvents, heavy metals); physiological effects of noise; hearing diagnostic characteristics of NIHL other than pure tone audiometry; effects of hearing conservation programs including hearing protective equipment and their evaluation; impairment compensation for workers with NIHL such as cost, quality of life, and therapeutic rehabilitation; health consequences of noise in workers in non-manufacturing industry (e.g., construction, mining), workers with specified professions (e.g., soldier, pilot, music player), and populations in specified areas (e.g., high noise exposure areas such as shooting ranges and airfields, and specified zones such as hospitals and schools). It follows that more attention should be paid to the relationship between hearing loss disability and anatomical/physiological structure/characteristics of hearing and other occupational hazards as well as noise. Otological consequences (e.g., tinnitus, vestibular function impairment) other than hearing loss, and the physiological, behavioral psychological, and social consequences of noise, should be considered too. In addition soldiers and workers with specified professions as well as manufacturing company workers exposed to noise,

should also receive our attention. That is, the influence of environmental noise should also be considered.

From a methodological point of view, most studies in Korea have been small-scale and mainly cross-sectional; case-control and cohort studies should be included. Studies across medicine (otology), speech audiology, industrial hygiene and (noise and vibration) engineering are greatly needed. Also, studies are needed for areas including: basic anthropometric studies in audiological field, such as ear (outer ear, middle ear) size of the Korean population and reference hearing level; standards of audiometer and audiometric test room for assuring accuracy of audiometry; standards for more rational application of criteria for NIHL and evaluation methods for noise exposure. In addition, development of systematic and comprehensive hearing conservation programs for preventing occupational hearing loss and preparation of technological, administrative systems for its settlement in the workplace are urgently needed.

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