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The impact of alcohol consumption on hearing loss in male workers with a focus on alcohol flushing reaction: the Kangbuk Samsung Cohort Study

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ABSTRACT

Background: Despite hearing loss being a prevalent chronic condition, estimated to nearly 20% of the global population by the World Health Organization, the specific association with individual lifestyle factors, particularly alcohol consumption, remains unclear. In South Korea, approximately 80% of the population engages in alcohol consumption, with a notably high prevalence among males, indicating a high-risk drinking pattern. Therefore, this study aimed to assess the correlation between alcohol consumption and hearing loss in male workers, as well as to analyze additional variables such as alcohol flushing reaction, with the intention of improving worker health.
Methods: The study was conducted from January 2012 to December 2019, targeting 114,114 participants who visited Kangbuk Samsung Hospital Total Healthcare Centers. Data were collected through pure-tone audiometry tests and alcohol-related questionnaire, and statistical analysis was performed using Cox regression analysis. Based on previous studies indicating a potential protective effect of light drinking on hearing loss, this group was designated as the reference. Additionally, stratified analyses were conducted based on the presence of alcohol flushing reaction and different working hours.
Results: The hazard ratio (95% confidence interval) for hearing loss was higher in the heavy drinking group (1.23 [1.11–1.37]) compared to the moderate drinking group (1.09 [0.98–1.20]). Stratified analyses revealed a significantly elevated the hazard ratio of hearing loss in groups with alcohol flushing reaction compared to those without this factor.
Conclusions: Our study demonstrated that moderate or heavy alcohol consumption in male workers can increase the risk of hearing loss, particularly in those with alcohol flushing reaction. These findings underscore the importance of addressing alcohol-related factors concerning hearing health among male workers.

Keywords: Hearing loss; Alcohol consumption; Alcohol flushing reaction; South Korea; Kangbuk Samsung Cohort Study

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Abbreviations

ALDH2: aldehyde dehydrogenase 2; ALT: alanine aminotransferase; AST: aspartate aminotransferase; BMI: body mass index; BP: blood pressure; CI: confidence interval; GABA: gamma-aminobutyric acid; HDL-C: high-density lipoprotein-cholesterol; HL: hearing loss; HR: hazard ratio; LDL-C: low-density lipoprotein-cholesterol; PTA: pure-tone audiometry; PY: person-years; SBP: systolic blood pressure.

Competing interests

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Lee W; Investigation: Lee W, Lee J, Jeong Y, Kim J; Methodology: Lee W, Lee J, Seo E, Kwon S; Supervision: Jeong J; Writing - original draft: Lee J; Writing - review & editing: Lee W.

BACKGROUND

Hearing loss (HL) is remarkably common and estimated by the World Health Organization to affect approximately 1.5 billion individuals, accounting for nearly 20% of the global population.[1] This prevalent condition imposes a significant burden on the daily lives of the affected individuals. HL is not merely a simple health condition but rather a complex disorder with multifaceted societal implications. It encompasses communication difficulties, diminishes social activities, restricts occupational functionality and contributes mental disorders such as depression.[2] While aging, past ear disorders, diabetes, occupational noise exposure, and ototoxic drug use have been identified as major causes of HL in the general population,[3,4] the impact of modifiable lifestyle factors, such as alcohol consumption, on HL remains unclear. In 2018, the alcohol consumption rate in South Korea was exceptionally high, reaching 79.7%. Although smoking rates have shown a gradual decline from 51.6% in 2005 to 43.1% in 2014, alcohol consumption rates have shown an increase to 69.8% in 2001 and 78.5% in 2005.[5]

While the negative health effects of alcohol consumption are well known, the relationship between alcohol consumption and hearing impairment remains unclear due to conflicting or inconclusive findings.[6] A previous study[7] have reported associations between alcohol consumption and HL, while others[8,9] have not. Previous studies have primarily utilized cross-sectional designs with data limited to the preceding year, and prospective studies examining this relationship are scarce. Gopinath et al.'s prospective study,[10] did not observe a significant association between alcohol consumption and the 5-year incidence of measured HL, although the study lacked sufficient validity to draw definitive conclusions. Another study[11] involving 26,809 men relied on subjectively reported hearing data rather than objective diagnostic measures. Previous studies that acknowledge the association between HL and alcohol were attempting to explain the hypothesis at the perspective about oxidative stress,[12,13] neurotransmission[14,15] or absorption of vitamin B12.[16,17] We identified the lack of large-scale prospective studies effectively evaluating this association. Consequently, we aimed to investigate the relationship between alcohol consumption and HL using data from the Kangbuk Samsung Health Study, a large-scale health cohort study in South Korea that included objectively collected audiometric data. To further clarify the pure association, our study focused exclusively on males, who have a significantly higher prevalence of alcohol consumption in terms of frequency and quantity, compared with females. In 2020, the monthly alcohol consumption rate in South Korea for males and females was 70.2% and 47.8%, respectively.[5] Notably, the rate of high risk drinking was considerably higher among males (21.6%) than among females (6.3%) in 2020. This indicates that males engage in high-risk drinking at a rate more than three times that of females. Hence, in our study, we investigated the relationship between alcohol consumption and HL among males.

We conducted two additional analyses to provide unique insights into this topic. The alcohol flushing reaction refers to a physiological response characterized by facial flushing during drinking. Up to 50% of Asians, including Koreans, have the aldehyde dehydrogenase 2 (ALDH2) gene mutation that causes the facial flushing response.[18] Previous review article found that individuals with flushing reaction had increased risks associated with type-2 diabetes and high blood pressure when consuming more than 4 drinks per week.[18] HL has been found to be related to diabetes[19] and hypertension.[20] Therefore, we conducted further analysis in the curiosity of whether there is an interesting relationship between HL and alcohol flush reaction. Long working hours have both short- and long-term negative effects on health.

However, South Korea still ranked fourth with an annual working time of 1,910 hours, higher than the average according to Organization for Economic Co-operation and Development.[21] These variables have a close connection to people's daily lives and are commonly observed and ALDH2 gene causing alcohol flush reaction accounts for considerable proportion, suggesting the potential for presenting interesting additional findings. Therefore, this study aimed to investigate the impact of alcohol flush reaction by stratifying the study participants into subgroups based on the presence of facial flushing and compared the risks.

METHODS

Study population

This cohort study was derived from a subsample of the Kangbuk Samsung Health Study conducted between January 2012 and December 2019. This cohort consisted of Korean men and women who participated in annual or biennial health screenings at Kangbuk Samsung Hospital Total Healthcare Centers in Seoul or Suwon. Among the 333,698 individuals who underwent comprehensive health screenings, including pure-tone audiometry (PTA), between January 2012 and December 2019, 180,948 were men. Individuals with i) missing important information such as responses to alcohol consumption and habit questionnaires and results of hearing tests (n = 31,549); ii) possibility of occupational noise exposure, which has ever done a hearing test up to 8 kHz according to the Korean Occupational Safety and Health Act (n = 32,989); iii) zero weekly working hours reported (n = 263); iv) pre-existing HL at the start of the follow-up period, defined as a pure-tone average of thresholds at 0.5, 1.0, and 2.0 kHz ≥ 25 dB in both ears (n = 7,687); v) and a history of malignant tumors, considering the possible ototoxicity of chemotherapy, or cardiovascular diseases and the possibility of reverse causation (n = 2,359) were excluded. Finally, 114,114 participants were included in the analysis (**Fig. 1**).

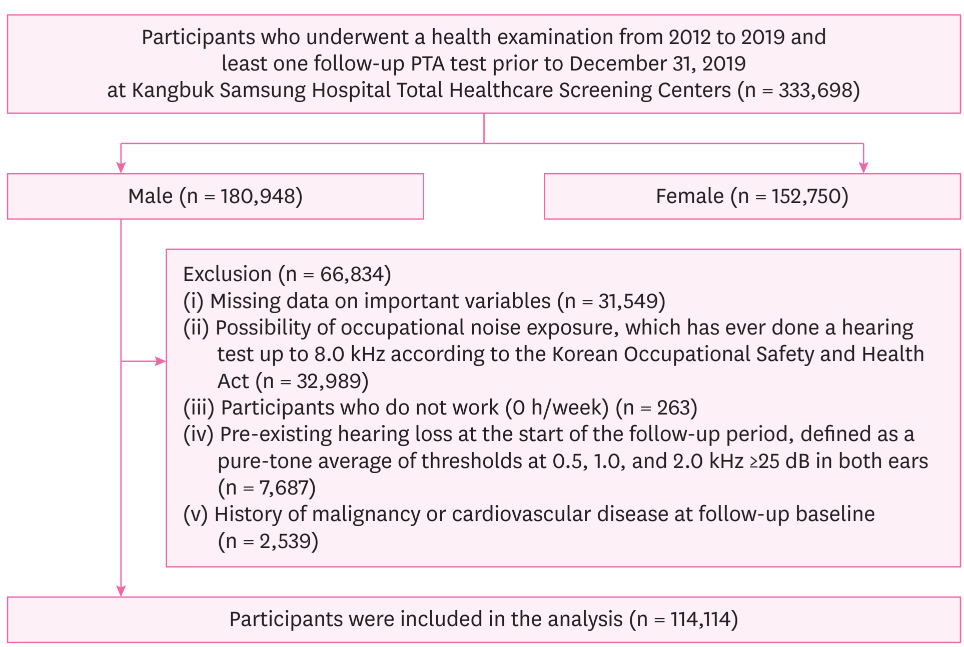

Fig. 1. Flowchart of study participants.
PTA: pure-tone audiometry.

Measurement of alcohol data

Alcohol consumption and Asian flush data were collected using standardized, self-administered questionnaires during comprehensive health screenings. The questionnaire included questions such as “How often do you drink?” and “How much do you usually drink on days you drink?” by type of alcoholic beverages (soju, beer, rice wine, wine, and liquor). Average daily alcohol consumption was calculated from the frequency and amount of alcohol by each type, and the amount of alcohol contained in one glass of each alcoholic beverage was referred to the low-risk drinking guideline of South Korea.[22] We categorized alcohol consumption levels into four groups: none, < 10 g/day, 10–30 g/day, and > 30 g/day, indicating non-drinking, light drinking, moderate drinking, and heavy drinking, respectively. The cut-off of this classification was established based on several studies.[23,24] In the question about Asian flush, participants who answered “Yes” to the question “Dose your face tun red immediately even with a small amount of alcohol?” were classified as alcohol flushers, while those who answered “No” were classified as alcohol non-flushers.

Measurement of auditory variables

During baseline and follow-up visits, PTA was performed by trained audiometric technicians using a GSI 67 audiometer (Bedford, MA, USA) equipped with TDH-39 supra-aural earphones (Telephonics Co., Farmingdale, NY, USA) in a dedicated sound-treated booth. Air conduction thresholds were measured in dB hearing levels for both ears at frequencies of 0.5, 1.0, and 2.0 kHz. Hearing levels of 25 dB and 40 dB are used as screening criteria for mild and moderate HL, respectively. The starting criterion of HL is defined as the level of 20 dB[25] or 25 dB,[26] and we defined bilateral HL as the average PTA threshold ≥ 25 dB at 0.5, 1.0, and 2.0 kHz in both ears.

According to the Korean Occupational Safety and Health Act, employees exposed to an equivalent sound pressure level of 85 dB averaged over 8 working hours in the workplace are required to undergo a hearing test at 2.0, 3.0, and 4.0 kHz. The Kangbuk Samsung Hospital Total Healthcare Centers preemptively tests 0.5 to 4.0 kHz, and only those with abnormalities are measured up to 8.0 kHz as a secondary test. Participants who underwent a hearing test up to 8.0 kHz were identified as having occupational noise exposure. Therefore, we used the presence or absence of data from the high-frequency hearing test as a proxy marker to determine exposure to occupational noise.

Measurement of other variables

Data on demographic characteristics, lifestyle factors, and medical history variables used in this study were obtained, from the Kangbuk Samsung Hospital Total Healthcare Centers during baseline and follow-up visits. These data were collected through standardized, self-administered questionnaires as part of the health checkup process mentioned earlier. The appropriate working hour standards may vary slightly according to the International Labour Organization and the labor laws in each country. Additionally, there were variations in actual working conditions across occupations, resulting in a diverse distribution of working hours within the cohort. By dividing the participants’ working hours by the midpoint, we found that 47.3% (n = 53,956) and 52.7% (n = 60,158) worked ≤ 48 and > 48 hour/week, respectively. Therefore, participants who reported working greater than 0 hour/week were classified as workers, and working hours were categorized as ≤ 48 hour/week and > 48 hour/week. The laboratory measurements used in this study were also conducted at Kangbuk Samsung Hospital Total Healthcare Centers during health check-ups. The Laboratory Medicine Department of Kangbuk Samsung Hospital in Seoul, Korea, is accredited by the Korean Society of Laboratory Medicine and the Korean Association of Quality Assurance for Clinical Laboratories.

Statistical analysis

The baseline characteristics of the study participants are presented according to their alcohol consumption status. The primary endpoint was the development of bilateral HL defined as a pure-tone average of thresholds at 0.5, 1.0, and 2.0 kHz ≥ 25 dB in both ears. Each participant was followed up from their baseline examination until either the development of bilateral HL or the last health examination conducted before December 31, 2019, whichever came first. As new-onset HL could have occurred at any time point between the visit at which HL was diagnosed by hearing tests and the prior visit, a parametric proportional hazards model was used to account for this type of interval censoring (stphtest command in Stata). The hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated for incident HL according to alcohol consumption status (non-drinking, light drinking, moderate drinking, and heavy drinking). The models were initially adjusted for age and further adjusted for center location (Seoul or Suwon), smoking status (never smoker, former smoker, or current smoker), physical activity (inactive, minimally active, engaging in health-enhancing physical activity, or unknown), income level (total monthly income divided into eight categories), obesity status (body mass index ≥ 25 kg/m^2), systolic blood pressure (SBP), glucose, low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C) and alanine aminotransferase (ALT).

We reviewed previous studies to establish reference standards based on statistical criteria. Interestingly, low or moderate alcohol consumption showed a protective effect against HL. For instance, a cross-sectional study conducted among participants of the Epidemiology of Hearing Loss Study (n = 3,571) identified an inverse relation between moderate alcohol consumption (> 140 g/week) in the previous year and HL.[8] Furthermore, previous studies,[6,27] including a European population-based multicenter study, have reported a protective effect on hearing associated with moderate alcohol consumption. Based on these findings, our study used light drinkers as a reference group for statistical analysis. All analyses were performed using Stata version 16.0 (Stata Corp LP, College Station, TX, USA). Statistical significance was set at $p < 0.05$.

RESULTS

Table 1 presents the baseline characteristics of the participants in this cohort study classified according to their alcohol consumption habits. The total number of participants was 114,114, including 4,607 non-drinkers, 40,709 light drinkers, 41,219 moderate drinkers, and 27,579 heavy drinkers. The mean age (standard deviation) of the study participants was 38.6 (7.3) years. Among the total population, 37.7% were current smokers, with proportions of 26.0%, 27.8%, 39.7%, and 51.1% among non-drinkers, light drinkers, moderate drinkers, and heavy drinkers, respectively, showing an increasing trend; contrastingly, alcohol flushing showed a downward trend, with proportions of 57.3%, 45.7%, 22.1%, and 11.8% in the groups, respectively. The mean number of weekly working hours for all participants was 44.7 hours, with no significant difference among the different alcohol consumption groups. Examining the biological markers indicating health effects, obesity rate was higher in heavy drinkers (47.2%) than in non-heavy drinkers, with an overall average of 40.5%. Furthermore, when comparing non-drinkers and heavy drinkers, an increase in values for blood pressure, triglyceride, and gamma-glutamyl transferase was observed in heavy drinkers.

Table 1. Baseline characteristics of study participants

Characteristics	Overall	Alcohol consumption habits				*p* for trend
		Non-drinking	Light drinking	Moderate drinking	Heavy drinking	
Number	114,114	4,607	40,709	41,219	27,579	-
Age (years)	38.6 (7.3)	38.2 (7.5)	37.8 (7.2)	38.6 (7.3)	39.7 (7.5)	< 0.001
Current smoker (%)	37.7	26.0	27.8	39.7	51.1	< 0.001
Alcohol flusher (%)	29.5	57.3	45.7	22.1	11.8	< 0.001
Working hours (hour/week)	44.7 (17.7)	44.9 (17.3)	44.9 (17.5)	44.9 (17.7)	44.3 (17.9)	< 0.001
Regular exercise[a] (%)	13.5	14.6	13.0	13.3	14.6	< 0.001
High education level[b] (%)	90.0	89.8	92.8	90.6	84.8	< 0.001
High income level[c] (%)	33.5	33.0	32.0	33.4	35.7	< 0.001
Obesity[d] (%)	40.5	38.2	35.4	41.3	47.2	< 0.001
BMI (kg/m^2)	24.6 (3.0)	24.4 (3.2)	24.2 (3.0)	24.7 (3.0)	25.0 (3.0)	< 0.001
Glucose (mg/dL)	95 (90–101)	93 (88–98)	94 (89–99)	95 (90–101)	97 (92–104)	< 0.001
Systolic BP (mmHg)	113.4 (11.3)	111.4 (11.2)	111.7 (10.9)	113.5 (11.2)	116.0 (11.6)	< 0.001
Diastolic BP (mmHg)	73.8 (9.4)	72.1 (9.0)	72.1 (9.0)	74.0 (9.3)	76.3 (9.7)	< 0.001
LDL-C (mg/dL)	128.7 (31.5)	127.5 (31.5)	128.5 (31.1)	129.1 (31.4)	128.6 (32.2)	0.008
HDL-C (mg/dL)	53.1 (13.0)	50.8 (12.0)	52.2 (12.4)	53.1 (13.0)	54.9 (13.8)	< 0.001
Triglycerides (mg/dL)	113 (80–163)	105 (75–149)	104 (75–148)	114 (81–164)	127 (89–185)	< 0.001
ALT (IU/L)	23 (17–34)	23 (16–35)	23 (16–33)	23 (17–34)	24 (18–36)	< 0.001
AST (IU/L)	21 (18–27)	21 (18–26)	21 (17–25)	21 (18–27)	23 (19–29)	< 0.001
GGT (IU/L)	30 (20–48)	23 (17–34)	24 (18–36)	31 (21–48)	43 (27–71)	< 0.001

Baseline characteristics of study participants according to alcohol consumption habits. Data are presented as the mean (standard deviation), median (interquartile range), or percentage.
BMI: body mass index; BP: blood pressure; LDL-C: low-density lipoprotein-cholesterol; HDL-C: high-density lipoprotein-cholesterol; ALT: alanine aminotransferase; AST: aspartate aminotransferase; GGT: gamma-glutamyl transferase.
[a]≥ 3 times/week, [b]≥ college graduation, [c]total monthly income ≥ 6 million KRW, [d]BMI ≥ 25 kg/m^2.

Table 2 presents the results of the Cox proportional hazards models analyzing the occurrence of HL based on different alcohol consumption. The models were adjusted for various factors including age; center location; smoking category; physical activity; income; obesity status; SBP, glucose, LDL-C, and HDL-C levels; and ALT. During the follow-up period of 509,545.32 person-years, 3,102 participants developed new-onset bilateral HL. The incidence rate of HL in the overall population was 6.0 per 1,000 person-years. The multivariable-adjusted HRs for incident HL were 1.09 (0.98–1.20) for moderate drinking and 1.23 (1.11–1.37) for heavy drinking compared with light drinking. These results indicated a significant association between alcohol consumption and the risk of developing HL, with an increasing risk pattern observed as alcohol intake increased.

Table 3 presents the results of subgroup analyses stratified by the presence of alcohol flushing among the participants. Multivariable analyses were performed within each subgroup using the same variables as in the previous analysis. The subgroups that showed significant associations were alcohol flushers with moderate and heavy drinking. Using light drinking as reference, the multivariable-adjusted HRs (95% CIs) for incident HL in each subgroup

Table 2. Hazard ratio for development of hearing loss in male workers by alcohol consumption habits

Alcohol consumption habits	PY	Incident cases	Incidence density (per 10^3 PY)	Adjusted HR (95% CI)		
				Model 1	Model 2	Model 3
Non-drinking	20,471.2	105	5.1	1.03 (0.84–1.26)	1.02 (0.81–1.28)	1.01 (0.80–1.27)
Light drinking	183,748.6	906	4.9	1.00 (reference)	1.00 (reference)	1.00 (reference)
Moderate drinking	185,640.9	1,116	6.0	1.3 (1.03–1.23)	1.10 (0.99–1.21)	1.09 (0.98–1.20)
Heavy drinking	119,684.6	975	8.1	1.34 (1.23–1.47)	1.26 (1.14–1.40)	1.23 (1.11–1.37)

Estimated from Cox proportional hazards models adjusted for multi-variables.
PY: person-years; HR: hazard ratio; CI: confidence interval.
Model 1: age adjusted.
Model 2: model 1 plus adjusted for center, smoking category, physical activity, and income.
Model 3: model 2 plus adjusted for obesity status, systolic blood pressure, glucose, low-density lipoprotein-cholesterol, high-density lipoprotein-cholesterol and alanine aminotransferase.

Table 3. Subgroup analysis for development of hearing loss by alcohol consumption habits

Stratification category	PY	Incident cases	Incidence density (per 10^3 PY)	Adjusted HR (95% CI)		
				Model 1	Model 2	Model 3
Alcohol flushers (n = 33,620)						
Non-drinking	11,464.2	59	5.1	1.03 (0.78–1.35)	1.07 (0.79–1.44)	1.06 (0.78–1.43)
Light drinking	83,143.5	418	5.0	1.00 (reference)	1.00 (reference)	1.00 (reference)
Moderate drinking	40,770.5	261	6.4	1.18 (1.01–1.38)	1.25 (1.05–1.48)	1.25 (1.05–1.49)
Heavy drinking	14,140.0	121	8.6	1.45 (1.18–1.77)	1.40 (1.11–1.77)	1.43 (1.12–1.81)
Alcohol non-flushers (n = 80,494)						
Non-drinking	9,007.0	46	5.1	1.05 (0.77–1.39)	0.98 (0.68–1.40)	0.98 (0.68–1.41)
Light drinking	100,605.1	488	4.8	1.00 (reference)	1.00 (reference)	1.00 (reference)
Moderate drinking	144,870.3	855	5.9	1.09 (0.98–1.22)	1.01 (0.89–1.15)	1.00 (0.88–1.14)
Heavy drinking	105,544.7	854	8.0	1.31 (1.17–1.46)	1.18 (1.04–1.34)	1.14 (1.00–1.30)

Estimated from Cox proportional hazards models adjusted for multi-variables.
PY: person-years; HR: hazard ratio; CI: confidence interval.
Model 1: age adjusted.
Model 2: model 1 plus adjusted for center, smoking category, physical activity, and income.
Model 3: model 2 plus adjusted for obesity status, systolic blood pressure, glucose, low-density lipoprotein-cholesterol, high-density lipoprotein-cholesterol and alanine aminotransferase.

were 1.25 (1.05–1.49) and 1.43 (1.12–1.81), respectively. Similar to the pattern in **Table 2**, the HRs of HL increased with increasing alcohol consumption in the moderate and heavy drinking groups among alcohol flushers and in the heavy drinking group among non-alcohol flushers. Both alcohol flushers and non-flushers showed a significant increased the HRs of HL with heavy drinking, but it was stronger in alcohol flushers (1.43 [1.12–1.81] vs. 1.14 [1.00–1.30]). In **Supplementary Table 1**, both longer and shorter working hours groups also showed a significant increased the HRs of HL with heavy drinking, but it was stronger in the longer working hours group (1.33 [1.14–1.55] vs. 1.15 [0.99–1.33]). When examining the HRs of flusher group compared with non-flusher group(reference) and the HRs of long working hours group compared with shorter working hours group (reference), no significant difference was observed between the groups.

DISCUSSION

Our study showed that moderate or heavy alcohol consumption in male workers can increase the risk of developing HL. Moderate or heavy drinking was also associated with a significant risk of HL (**Table 2**). This finding is consistent with the result of previous study that have shown the odds ratio of HL increased when comparing hazardous and appropriate drinking.[7] In exploring the possible hypothesis behind this, from a neurological perspective, alcohol consumption can cause overlapping damage to the nervous system, leading to HL. The olivocochlear efferent system is gamma-aminobutyric acid (GABA)-ergic and innervates sensory cells and sensory neurons of the inner ear.[14] In the central nervous system, alcohol enhances inhibitory neurotransmission by modulating GABA receptors.[15] Through this neurotransmission explanation, we could infer that alcohol could disrupt the normal function of inner ear, thereby interfering with auditory pathway. A previous study[28] using magnetoencephalography and electroencephalography found that alcohol bilaterally impairs the detection of sounds and deviance in the auditory cortex.

Alcohol consumption is also associated with oxidative stress.[12] Oxidative stress can contribute to the pathophysiology of hearing impairment by damaging cochlear hair cells through protein and lipid degradation, along with DNA damage and increased apoptosis.[13] Additionally, chronic alcohol exposure impairs folate absorption by inhibiting expression of the reduced folate carrier and decreasing the hepatic uptake,[16] which may contribute to HL. Vitamin B12 plays a crucial role in cell metabolism, vascular function, and myelin synthesis; therefore, a deficiency can potentially lead to HL.[17]

In both alcohol flushers and non-flushers groups, the higher the drinking consumption, the higher the HRs of HL. In addition, when comparing the HRs of HL in heavy drinking between alcohol flushers and non-flushers groups, alcohol flusher group showed the higher HRs. Normally, alcohol is metabolized by ALDH2. However, if there is a deficiency of the ALDH2, alcohol cannot be properly broken down, leading the manifestation of facial flushing, known as alcohol flushing reaction. From a genetic perspective, individuals with a mutant of the ALDH2 gene lack functional ALDH2. Alcohol flushing reaction can serve as an effective proxy to distinguish individuals with this deficiency mutation and has a 90% sensitivity and specificity in predicting ALDH2 gene variations in East Asian populations.[29,30] Applying this to our study, it is likely that the group of male workers with alcohol flush had a higher probability of having the ALDH2 deficiency mutation, which impairs normal alcohol metabolism. Consequently, we were able to infer that alcohol flushers may not break down alcohol properly, so they may be more vulnerable to alcohol than non-flushers when consumed with the same amount of alcohol, making them more susceptible to alcohol-induced HL.

However, this study has several limitations. Leisure noise exposure, which accounts for the highest proportion of noise exposure compared with personal noise exposure,[31] was not considered in our study. Data for important variables such as alcohol consumption and alcohol flushing reactions were collected through self-reported questionnaires, which may introduce bias. In our study, the drinking rate over 120 g/day was calculated very high at 3.95%. This was likely due to the complexity of the questionnaire that required answering the amounts of alcohol consumed by the various types of alcoholic beverages and the uncertainty in the duration specification of the questionnaire. The generalizability of this cohort to the entire population may be limited. In addition, the history of ear diseases such as otitis media and the types of employment could not be considered. Nevertheless, this study has several strengths compared with previous studies on similar topics. By minimizing the influence of aging, the most common cause of HL, through the relatively young average age of the participants (38.6 years), the potential for bias was greatly reduced. Unlike previous studies, which have not extensively addressed occupational noise exposure, this study excluded for occupational noise exposure, which accounts for nearly half (49.2%) of occupational diseases, except cerebrovascular and musculoskeletal disorders.[32] Additionally, by incorporating variables such as alcohol flushing reaction, this study provided unique insights. With a large-scale cohort of nearly 115,000 participants and standardized data collection, the reliability and validity of the results are high.

CONCLUSIONS

Studies on HL and its correlation with alcohol consumption in male workers, especially those with frequent alcohol intake, hold significant importance in improving worker health. Although HL has traditionally been considered an inevitable part of aging, several healthy lifestyle adjustments have been shown to delay its onset. This study highlights the fact that moderate-to-severe alcohol consumption can increase the risk of HL in male workers. Furthermore, groups with alcohol flushing reactions may be more susceptible to this risk.

Therefore, male workers, especially those with this characteristic, would benefit from proactive measures to improve their drinking habits. Although the associations found in this study are significant, future research may provide a clearer understanding of the relationship between HL and alcohol consumption.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Subgroup analysis for development of hearing loss by alcohol consumption habits

REFERENCES

1. WHO health topics deafness and hearing loss. https://www.who.int/health-topics/hearing-loss#tab=tab_1. Updated 2016. Accessed June 11, 2023.
2. Olusanya BO, Neumann KJ, Saunders JE. The global burden of disabling hearing impairment: a call to action. Bull World Health Organ 2014;92(5):367-73. PUBMED | CROSSREF
3. Agrawal Y, Platz EA, Niparko JK. Prevalence of hearing loss and differences by demographic characteristics among US adults: data from the National Health and Nutrition Examination Survey, 1999-2004. Arch Intern Med 2008;168(14):1522-30. PUBMED | CROSSREF
4. Nash SD, Cruickshanks KJ, Klein R, Klein BE, Nieto FJ, Huang GH, et al. The prevalence of hearing impairment and associated risk factors: the Beaver Dam Offspring Study. Arch Otolaryngol Head Neck Surg 2011;137(5):432-9. PUBMED | CROSSREF
5. Korea Institute for Health Promotion and Development statistical information system. https://www.khepi.or.kr/board?menuId=MENU01152&siteId=null-. Updated 2021. Accessed June 11, 2023.
6. Fransen E, Topsakal V, Hendrickx JJ, Van Laer L, Huyghe JR, Van Eyken E, et al. Occupational noise, smoking, and a high body mass index are risk factors for age-related hearing impairment and moderate alcohol consumption is protective: a European population-based multicenter study. J Assoc Res Otolaryngol 2008;9(3):264-76. PUBMED | CROSSREF
7. Park JA, Suh MJ. Hazardous alcohol consumption and the risk of hearing impairment in adults based on the Korean National Health and Nutrition Survey: a retrospective study. J Audiol Otol 2019;23(2):63-8. PUBMED | CROSSREF
8. Popelka MM, Cruickshanks KJ, Wiley TL, Tweed TS, Klein BE, Klein R, et al. Moderate alcohol consumption and hearing loss: a protective effect. J Am Geriatr Soc 2000;48(10):1273-8. PUBMED | CROSSREF
9. Dawes P, Cruickshanks KJ, Moore DR, Edmondson-Jones M, McCormack A, Fortnum H, et al. Cigarette smoking, passive smoking, alcohol consumption, and hearing loss. J Assoc Res Otolaryngol 2014;15(4):663-74. PUBMED | CROSSREF
10. Gopinath B, Flood VM, McMahon CM, Burlutsky G, Smith W, Mitchell P. The effects of smoking and alcohol consumption on age-related hearing loss: the Blue Mountains Hearing Study. Ear Hear 2010;31(2):277-82. PUBMED | CROSSREF
11. Curhan SG, Eavey R, Shargorodsky J, Curhan GC. Prospective study of alcohol use and hearing loss in men. Ear Hear 2011;32(1):46-52. PUBMED | CROSSREF
12. Wu D, Cederbaum AI. Alcohol, oxidative stress, and free radical damage. Alcohol Res Health 2003;27(4):277-84. PUBMED
13. Kamogashira T, Fujimoto C, Yamasoba T. Reactive oxygen species, apoptosis, and mitochondrial dysfunction in hearing loss. BioMed Res Int 2015;2015:617207. PUBMED | CROSSREF
14. Maison SF, Rosahl TW, Homanics GE, Liberman MC. Functional role of GABAergic innervation of the cochlea: phenotypic analysis of mice lacking GABA(A) receptor subunits α 1, α 2, α 5, α 6, β 2, β 3, or δ. J Neurosci 2006;26(40):10315-26. PUBMED | CROSSREF
15. Olsen RW, Liang J. Role of $GABA_A$ receptors in alcohol use disorders suggested by chronic intermittent ethanol (CIE) rodent model. Mol Brain 2017;10(1):45. PUBMED | CROSSREF
16. Halsted CH, Villanueva JA, Devlin AM, Chandler CJ. Metabolic interactions of alcohol and folate. J Nutr 2002;132(8 Suppl):2367S-2372S. PUBMED | CROSSREF

https://doi.org/10.35371/aoem.2024.36.e1

17. Houston DK, Johnson MA, Nozza RJ, Gunter EW, Shea KJ, Cutler GM, et al. Age-related hearing loss, vitamin B-12, and folate in elderly women. Am J Clin Nutr 1999;69(3):564-71. PUBMED | CROSSREF
18. Lee S, Kim JS, Jung JG, Oh MK, Chung TH, Kim J. Korean alcohol guidelines for moderate drinking based on facial flushing. Korean J Fam Med 2019;40(4):204-11. PUBMED | CROSSREF
19. Bainbridge KE, Hoffman HJ, Cowie CC. Diabetes and hearing impairment in the United States: audiometric evidence from the National Health and Nutrition Examination Survey, 1999 to 2004. Ann Intern Med 2008;149(1):1-10. PUBMED | CROSSREF
20. Nawaz MU, Vinayak S, Rivera E, Elahi K, Tahir H, Ahuja V, et al. Association between hypertension and hearing loss. Cureus 2021;13(9):e18025. PUBMED
21. OECD statistical information system. https://stats.oecd.org/. Updated 2022. Accessed June 11, 2023.
22. Korea Institute for Health Promotion and Development statistical information system. https://www.khepi.or.kr/board/view?pageNum=1&rowCnt=10&no1=1&linkId=24630&menuId=MENU01181. Updated 2013. Accessed October 31, 2023.
23. Kim J. Association between amount of alcohol consumption and serum fasting glucose level in Korean male in their 40s and 50s: the Seventh Korea National Health and Nutrition Examination Survey 2016–2018. Korean J Fam Pract 2022;12(5):320-5. CROSSREF
24. Choi S, Lee G, Kang J, Park SM, Sung E, Shin HC, et al. Association of change in alcohol consumption on fasting serum glucose, insulin resistance, and beta cell function among Korean men. Alcohol 2020;85:127-33. PUBMED | CROSSREF
25. Olusanya BO, Davis AC, Hoffman HJ. Hearing loss grades and the International classification of functioning, disability and health. Bull World Health Organ 2019;97(10):725-8. PUBMED | CROSSREF
26. Clark JG. Uses and abuses of hearing loss classification. ASHA 1981;23(7):493-500. PUBMED
27. Helzner EP, Cauley JA, Pratt SR, Wisniewski SR, Zmuda JM, Talbott EO, et al. Race and sex differences in age-related hearing loss: the Health, Aging and Body Composition Study. J Am Geriatr Soc 2005;53(12):2119-27. PUBMED | CROSSREF
28. Kähkönen S, Marttinen Rossi E, Yamashita H. Alcohol impairs auditory processing of frequency changes and novel sounds: a combined MEG and EEG study. Psychopharmacology (Berl) 2005;177(4):366-72. PUBMED | CROSSREF
29. Yokoyama A, Kato H, Yokoyama T, Igaki H, Tsujinaka T, Muto M, et al. Esophageal squamous cell carcinoma and aldehyde dehydrogenase-2 genotypes in Japanese females. Alcohol Clin Exp Res 2006;30(3):491-500. PUBMED | CROSSREF
30. Kim JS, Kim YJ, Kim TY, Song JY, Cho YH, Park YC, et al. Association of ALDH2 polymorphism with sensitivity to acetaldehyde-induced micronuclei and facial flushing after alcohol intake. Toxicology 2005;210(2-3):169-74. PUBMED | CROSSREF
31. Kim GS. Noise and hearing 2 - noise exposure to general public. K Ind Health 2009;258:34-44. PUBMED
32. KOSHA statistical information system, results of 2019 workers' health examination. https://www.kosha.or.kr/kosha/data/healthExamination.do. Updated 2021. Accessed June 11, 2023.