Original Article



# Occupational noise exposure and hypertension: a case-control study

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**Background:** Occupational noise exposure in the workplace is a significant health problem and hypertension is a widespread chronic disease. This study aimed to investigate whether occupational noise exposure is associated with hypertension in a Chinese population.

**Methods:** A total of 286 hypertensive workers and 630 normotensive workers were enrolled and analyzed in a case-control study.

**Results:** We revealed that workers exposed to noise can increase the risk of hypertension (adjusted OR 1.52, 95% CI: 1.11–2.08). This effect was more pronounced in ever smoking group (adjusted OR 2.54, 95% CI: 1.16–5.53). When noise exposure combined with never drinking status, it can reduce the risk of hypertension (adjusted OR 1.48, less than 1.52).

**Conclusions:** Our results provide a clue that occupational noise exposure may increase the risk of hypertension in a Chinese population.

**Keywords:** Occupational noise exposure; hypertension; risk

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## Introduction

Occupational noise exposure in the workplace is a significant health problem in developed and developing countries. In the US, more than 10% of the occupational population are exposed to hazardous noise levels (http://www.cdc.gov/niosh/topics/noise/). In Europe, approximately 20% of workers are exposed to intense noise during at least half of their working time (European Communities 2004). In some developing countries (such as China, India, etc.), this problem may be more serious.

While noise-induced hearing loss (NIHL) is the most investigated and reported health effect related to noise exposure (1-3), other effects such as sleep disturbances (4), digestive disorders (5), changes in the serum cortisol levels (6), higher incidence of occupational accidents and cardiovascular diseases are also considered to be associated with noise exposure (7,8).

Hypertension, which is widely accepted as one of the most common chronic diseases in adults, is a significant risk factor for cardiovascular diseases. It is predicted that 26.4%

 

of the world's adult population will have hypertension by the year 2025 (9) and approximately 13.5% of the deaths worldwide could be attributed to hypertension (10). The biological possibility of hypertension induced by occupational noise exposure has been described by several studies (8,11-13). However, the association between occupational noise exposure and hypertension continues to be controversial, with several studies showing an association between occupational noise exposure and the risk of persistent hypertension or sustained elevation of blood pressure (14-18), while results from other studies are inconsistent (19-22). The possible reasons for this inconsistency include differences in exposure assessment, study design, numbers of subjects and abilities to control for potential confounding variables.

The aim of this study was to investigate whether occupational noise exposure is associated with a risk of hypertension in a Chinese Han population. A case-control study was conducted which included 286 hypertensive workers and 630 normotensive workers.

## Methods

### *Subjects*

The study protocol was approved by the institutional review board of Jiangsu Provincial Center for Disease Prevention and Control. To investigate the association between noise exposure and high blood pressure, we performed an unpaired case-control study including 286 hypertensive workers and 630 normotensive workers between October 2013 and January 2014. All the subjects were Han Chinese. In total, 916 subjects (who had worked a total of 5–30 years) were included and divided into two groups: 454 volunteers identified as noise exposure workers were selected from the Datun Coal and Electricity Company (Xuzhou, China) and 462 volunteers identified as non-noise exposure workers were selected from schools in Datun (Xuzhou, China). The inclusion criteria were as follows: the selected workers were employed for at least 5 years; they had normal blood pressure before being employed (the subjects all had a healthy examination before they were employed); and the selected subjects had not routinely been exposed to other chemical or physical factors associated with hypertension (e.g., vibrations, heat ), had no medical factors or diseases that could affect blood pressure, had no family history of hypertension, and had no habit of using hearing protection. The subjects were defined as "ever smokers" if they had smoked 100 cigarettes or more in their lifetimes. The subjects were defined as "ever drinkers" if they had consumed three or more alcoholic drinks per week for at least 1 year (23).

### *Questionnaire*

Structured questionnaires were conducted in face-to-face interviews with each subject. The information collected in the questionnaire included demographic characteristics, lifestyle habits (smoking and alcohol consumption), work history, physical and chemical factor exposure (include noise exposure), disease history, family history of hypertension, informed consent, and other data. All the volunteers were interviewed.

### *Definition of noise exposure and hypertension*

We used sound pressure noise metres (Noise-Pro, Quest, Oconomowoc WI, USA) to detect noise exposure levels at 10 am, 3 pm, 5 pm for three consecutive days at each workplace, according to the China National Criteria for Noise in the Workplace (GBZ43-2002, http://www.zybw.net), and obtained records by normalizing the equivalent continuous A-weighted sound pressure to a nominal 8 h per day (Lex.8 h). Noise exposure levels of teachers of less than 70 dB (A) were defined as non-noise exposure workers [noise exposure levels less than 70 dB (A) do not require noise assessment every year]. Workers of the Datun Coal and Electricity Company with noise exposure levels of more than 80 dB (A), were defined as noise exposure workers [according to the Terms of Occupational Health (GBZ/T 224-2010)].

Blood pressure measurements were taken by the attending physician three times on the left arm with the patient sitting. The blood pressure value used was the mean of these three measurements. The hypertensive workers were defined as having systolic pressure no less than 140 mmHg and/or a diastolic pressure no less than 90 mmHg; subjects with pressures outside these ranges were defined as normotensive workers. Subjects using anti- hypertensive drugs were also classified as hypertensive workers.

### *Statistical analysis*

The data were analysed using SAS statistical software (version 9.1.3; SAS Institute, Cary, NC, USA). Categorical data were analysed using two-sided $\chi^2$ tests. Continuous data

 

**Table 1** Demographic and occupational characteristics of hypertensive and normotensive subjects

| Variables | Normotensive (n=630), n (%) | Hypertensive (n=286), n (%) | P* |
|---|---|---|---|
| Age (years) | 39.3±6.9 | 47.3±7.6 | <0.001# |
| <35 | 160 (25.4) | 43 (15.0) | <0.001 |
| 35–45 | 359 (57.0) | 138 (48.3) | |
| >45 | 111 (17.6) | 105 (36.7) | |
| Gender | | | <0.001 |
| Male | 277 (44.0) | 198 (69.2) | |
| Female | 353 (56.0) | 88 (30.8) | |
| Smoking status | | | 0.830 |
| Never | 530 (84.1) | 239 (83.6) | |
| Ever | 100 (15.9) | 47 (16.4) | |
| Drinking status | | | 0.443 |
| Never | 579 (91.9) | 267 (93.4) | |
| Ever | 51 (8.1) | 19 (6.6) | |
| Exposure time (years) | 13.6±9.9 | 13.7±11.4 | 0.910# |
| ≤20 | 444 (70.5) | 186 (65.0) | 0.099 |
| >20 | 186 (29.5) | 100 (35.0) | |

*, two-sided $\chi^2$ test for age, sex, smoking, drinking and exposure time comparison between the normotensive and hypertensive group; b, two-sided *t*-test for the frequency distributions of selected variables between the normotensive and hypertensive group.

were calculated using independent-sample two-sided *t*-tests. Unconditional multivariate logistic regressions were applied to compute odds ratios (ORs) and 95% confidence intervals (CIs) to estimate the associations between noise exposure status and risk of hypertension. Adjusted ORs and 95% CIs were calculated by multivariate logistic regression adjusted for age, sex, smoking and drinking status. Furthermore, stratification analyses were performed within different subgroups categorized by noise exposure time, smoking status, and drinking status. All the tests were two-sided and a value of P<0.05 was considered statistically significant.

## Results

### *Characteristics of the study subjects*

The demographic and occupational characteristics of the 286 hypertensive workers and 630 normotensive workers are shown in *Table 1*. Overall, no significant differences were detected in smoking status (P=0.830), drinking status (P=0.443) and noise exposure time (P=0.910). However, we found that hypertensive workers (47.3±7.6 years) were older than normotensive workers (39.3±6.9 years), with P<0.001. When we divided their ages into 3 groups, <35, 35–45, and >45 years, we found that there were more subjects <35 years in the normotensive workers group than in the hypertensive workers group (25.4% *vs.* 15.0%), but fewer subjects >45 years in the normotensive workers group than in the hypertensive workers group (17.6% *vs.* 36.7%). The proportion of male workers in the normotensive workers group was less than in the hypertensive workers group (44.0% *vs.* 69.2%). The effects of smoking and drinking were not analysed quantitatively since the majority of subjects who were smokers and drinkers were light consumers.

### *Association of noise exposure with the risk of high blood pressure.*

As presented in *Table 2*, among the normotensive workers, the proportions of noise exposure workers and non-noise exposure workers were 46.8% and 53.2%, respectively, and among hypertensive workers, the proportions of noise exposure workers and non-noise exposure workers were

 

**Table 2** Associations of noise exposure with the risk of hypertension

| Variables | Normotensive (n=630), n (%) | Hypertensive (n=286), n (%) | OR (95%CI) | Adjusted OR (95% CI)[#] | P* |
|---|---|---|---|---|---|
| Noise exposure status | – | – | – | – | 0.014 |
| Non-noise exposure | 335 (53.2) | 127 (44.4) | 1.00 | 1.00 | |
| Noise exposure | 295 (46.8) | 159 (55.6) | 1.42 (1.07–1.88) | 1.52 (1.11–2.08) | 0.014 |

*, two-sided $\chi^2$ test for the frequency distributions of noise exposure between the normotensive workers and hypertensive workers; #, adjusted for age, sex, smoking and drinking status.

**Table 3** Stratified analysis of noise exposure associated with hypertension risk

| Variables | Normotensive | | Hypertensive | | OR (95%CI) | Adjusted OR (95% CI)[#] | P* |
|---|---|---|---|---|---|---|---|
| | No noise exposure (n=335), n (%) | Noise exposure (n=295), n (%) | No noise exposure (n=127), n (%) | Noise exposure (n=159), n (%) | | | |
| Exposure time (years) | | | | | | | |
| ≤20 | 207 (32.9) | 237 (37.6) | 67 (18.9) | 119 (10.6) | 1.55 (1.09–2.21) | 1.21 (0.79–1.87) | 0.014 |
| >20 | 128 (44.8) | 58 (20.2) | 60 (21.0) | 40 (14.0) | 1.47 (0.89–2.44) | 1.72 (0.98–3.01) | 0.134 |
| Smoking status | | | | | | | |
| Never | 276 (35.9) | 254 (33.0) | 109 (14.2) | 130 (16.9) | 1.30 (0.95–1.36) | 1.41 (0.99–2.01) | 0.097 |
| Ever | 59 (40.1) | 41 (27.9) | 18 (12.2) | 29 (19.7) | 2.32 (1.14–4.72) | 2.54 (1.16–5.53) | 0.019 |
| Drinking status | | | | | | | |
| Never | 305 (32.4) | 274 (36.1) | 119 (14.1) | 148 (17.5) | 1.38 (1.04–1.85) | 1.48 (1.06–2.06) | 0.028 |
| Ever | 30 (42.9) | 21 (30.0) | 8 (11.4) | 11 (15.7) | 1.96 (0.68–5.71) | 3.68 (0.89–15.24) | 0.212 |

*, two-sided $\chi^2$ test for the frequency distributions of selected variables between the normotensive workers and hypertensive workers; #, adjusted for age, sex, smoking and drinking status.

55.6% and 44.4% (P=0.014). When we used the non-noise exposure workers for reference, we found that workers exposed to noise showed an increased risk of hypertension (adjusted OR 1.52, 95% CI: 1.11–2.08).

### *Stratified analysis of noise exposure associated with hypertension risk*

As shown in *Table 3*, the increased risk effects were more evident in the "ever smoked" group (adjusted OR 2.54, 95% CI: 1.16–5.53). In the "never drink alcohol" group, noise exposure can increase the risk of hypertension, but the risk is lower than the main effect (adjusted OR 1.48, less than 1.52). However, no increased risk was observed in the other groups.

## Discussion

In this case-control study, we explored the association between noise exposure and hypertension. We found that subjects with occupational noise exposure had an increased risk of hypertension compared to subjects with non-noise exposure, with the risk being more pronounced in the "ever smoked" group of workers.

In animal studies, spontaneously hypertensive (SH) rats were used to investigate the association between noise exposure and hypertension (24). Borg found that much greater loss of cochlear hair cells in SH rats than in normotensive rats when exposure to high- frequency noise of 100 dB (25). Axelsson *et al.* also reported that exposure to noise of 100 dB for 10 h induced constriction of precapillary sphincters in radial arterioles and then reduced the blood

 

flow. This phenomenon occurred in both hypertensive and normotensive rats while the effect was more pronounced in the hypertensive group (26). One possible explanation for this difference was vascular damage due to vascular factors such as hypertension. In humans, numerous studies have reported that occupational noise exposure is associated with hypertension (14-17). An exposure-response association between noise-exposure levels and the risk of hypertension was also found in a prospective cohort study (27). This association exist may be due to noise exposure activates the sympathetic and endocrine systems, affecting the humoral and metabolic states of the human organism, leading to the elevation of blood pressure and other biological risk factors (9). Similarly, we found that noise exposure could increase the risk of hypertension in a Chinese population (adjusted OR 1.52, 95% CI: 1.11–2.08).

In general, the cumulative noise exposure (CNE) increases when the noise exposure duration was longer, and the subjects had a higher risk of hypertension (28). Risk can also be influenced by age (29,30) and exposure time (workers exposed to noise longer may be older than workers exposed to noise for a shorter period of time). In our study, we found noise exposure workers in the ≤20 years old exposure group were more susceptible to hypertension (OR 1.55); however, when adjusted for age, sex, smoking and drinking, no increased risk was observed. Similarly, in the >20 years old exposure group, no increased risk was observed. Noise exposure levels are also important risk factors for developing hypertension, and an exposure-response association between noise exposure levels and the risk of hypertension has also been reported (27). However, in our study, noise assessment of non-noise exposure workers was not required, and the data of non-noise exposure workers were missing; therefore, we did not analyse the association between noise exposure and hypertension in the stratification analysis.

Smoking releases norepinephrine through nicotine-induced adrenaline nerve endings leading to the increase of blood pressure. In addition, smoking also causes an acute and marked reduction in radial artery compliance, but this effect being independent of the increase in blood pressure (31). Some studies have also reported that smoking is a risk factor for hypertension. Similarly, in our study, when noise exposure was combined with "ever smoked" status, the increased risk of hypertension was more evident (adjusted OR 2.54, which is higher than 1.52), although the smokers in this study were light consumers (pack-year 8.2). A moderate level of alcohol consumption was associated with an increase in cardiac output and heart rate, leading to increased sympathetic nerve activity (32). Alcohol may also alter the cell membrane by inhibiting intracellular sodium transport, allowing more calcium to enter (33). Alcohol consumption has been shown to be associated with hypertension in many studies (29,34). In this study, we found that in the "never drink" status group, noise exposure could decrease the risk of hypertension (adjusted OR 1.48, which is lower than 1.52).

This study had several limitations that should be considered. First, because it is a cross-sectional study, the direction of association was not clear. Second, some demographic and lifestyle risk factors, such as body mass index (BMI), were not considered. Third, data regarding endogenous variables such as glucose levels, blood cholesterol, cortisol, etc., directly related to coronary heart disease, were omitted from this study. Fourth, the noise exposure levels of non-noise exposure subjects (teachers) were not tested. Finally, the disease outcome used in this investigation was a self-report of the doctor's diagnosis, which may produce some bias and result in disease misclassification due to inaccurate knowledge or non-reporting.

## Conclusions

Our study provided evidence that individuals with occupational noise exposure have an increased risk for hypertension in a Chinese population, this effect was more pronounced in the stratification analysis (in the "ever smoking" group). However, these results need to be validated in a larger population or in a prospective study.

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## Footnote

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jphe.2018.12.01). HS serves as an unpaid Section Editor of *Journal of Public Health and Emergency* from Jan 2017 to Dec 2019. BZ serves as an Editor-in-Chief of *Journal of Public Health and Emergency* from January 2017 to December 2022. The other authors have no conflicts of

 

interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Human biological samples and animal subjects are not involved in this study, so we don't need to apply for the ethics approval and patients' informed consent.



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