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Original

Noise Annoyance and Perception by Low-Frequency Noise in Students

Siavash Etemadinezhad[1], Milad Abbasi[2], Ahmad Alizadeh Larimi[3], Jamshid Yazdani Charati[4], Roghay'eh Jaffari Talaar poshti[5]*

[1] Associate Professor, Department of Occupational Medicine, Health Sciences Research Center, Mazandaran University of Medical Sciences, Sari, Iran• [2] PhD student, Student's Scientific Research Center, Tehran University of Medical Sciences, Tehran, Iran• [3] Lecturer, Department of Occupational Health, Faculty of Health, Mazandaran University of Medical Sciences, Sari, Iran• [4] Associate Professor, Department of Biostatistics, Health Sciences Research Center, Mazandaran University of Medical Sciences, Sari, Iran• [5]MSc Student, Department of Occupational Health, School of Public Health, Mazandaran, University of Medical Sciences, Sari, Iran• *Corresponding author: Roghay'eh Jaffari Talaar poshti, Email: Roghayejafari69@gmail.com Tel:+98- 011-4220381

Abstract

Background: Low-frequency noise as a detrimental occupational and environmental factor which can cause noise annoyance. In addition to noise, factors such as sensitivity and awareness of adverse health effects of noise seem to play an important role in causing annoyance. Therefore, this study aimed to investigate the association of noise annoyance and loudness perception caused by exposure to low-frequency noise with noise sensitivity. **Methods:** To achieve this goal, 80 students were exposed to low-frequency noise exposure at 65 dBA in an acoustic room. After one hour of exposure, the subjects completed the Weinstein's Noise Sensitivity Scale, Loudness Perception Scale, and Noise Annoyance Scale. Data were analyzed using Mann-Whitney, Kruskal-Wallis test and the Multivariate Analysis of variance (MANOVA). **Results:** The results showed that the mean score of noise annoyance and loudness perception was significantly higher in the group with high noise sensitivity. Also, increasing the awareness of the harmful effects of noise significantly increased the level of annoyance and loudness perception of individuals. The results of MANOVA showed that noise sensitivity has a significant effect on both the response variables. Also, awareness of the harmful effects of noise only affects loudness perception. The interaction effect of two independent variables was not significant on any of the response variables. **Conclusion:** In general, it can be concluded that noise sensitivity and awareness of the harmful effects of noise are two important factors that exacerbate the annoyance caused by exposure to low-frequency noise.

Keywords: Noise annoyance; Loudness perception; Low-frequency noise; Audio sensitivity

Introduction

Noise is unpleasant and unwanted sound that nowadays as a detrimental factor has attracted the attention of many researchers.[1] A lot of studies have been done on the effects of noise which is often about the negative effects noise on health.[2, 3] Among the various types of noise pollution, low-frequency noise due to the important and unique features has attracted attention. Road vehicles, airplanes, industrial machinery, the mine blast, wind turbines, compressors, air

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conditioning systems are major sources of low-frequency noise produced in the living and working environment.[4] Exposure to low-frequency noise, in the frequency range of 10-200 Hz, is associated with several health problems.[5, 6]

Noise annoyance is one of the most common complains attributed to the low-frequency noise exposure.[5, 7-9] The concept of noise annoyance shows the degree of dissatisfaction, worry, inconvenience, harassment, and provocation, loss of the ability to control and loss of orientation in facing the noise.[10, 11] Although, noise annoyance is not fully explainable due to exposure to noise, part of it is related to individual and social factors.[12] Among these factors, the noise sensitivity and noise attitude are of the most important individual factors. The noise sensitivity is an innate trait that enhances a person's predisposition to Annoyance and discomfort resulting from the noise exposure .[13, 14] Monazzam et al. showed that noise sensitivity -as a mediator factor- aggravate noise effects and create noise annoyance in people exposed to noise.[15] Other studies have also shown that people more sensitive to noise report more annoyance.[16]

Noise annoyance, in turn, causes other health problems. In this case, Stanfeld stated that noise annoyance and mental discomfort have cross-impact on each other.[17] Therefore the occurrence of each of these disorders can be aggravated by the other.[17] Also, the results of the studies of the World Health Organization showed that noise annoyance is one of the risk factors which can reduce health-related quality of life.[18] On the other hand, noise annoyance affects the quality of sleep and causes sleep disorder.[19-21] Several studies have so far investigated the relationship between low-frequency noise exposure and annoyance. Additionally, in some cases, there have been inconsistent results. Therefore, in this study, the association between exposure to low-frequency noise and annoyance was examined.

Methods

This study was conducted in 2018 on bachelor's and master's students of Mazandaran University of medical sciences. Samples were chosen from the students in the faculty of health at Mazandaran University of medical sciences. Samples were in the age range of 20 to 30 with no history of hearing problems or hearing loss. The sample size was estimated to be 68. Finally, 80 students (40 girls and 40 boys) were enrolled in the study. All of the students participated in the study, were informed about the study and signed the consent form (Ethics committee registration number 2741). The candidates were asked to go to the lab in the morning. They were asked in the evening of the day before the intervention to have an 8-hour sleep.

To investigate the effect of low-frequency noise on noise annoyance, low-frequency noise in the laboratory environment generated using CoolEdit software (version 2.00). The noise pressure level of 65 dBA was set at the test room. The frequency distribution of noise in octave central band frequencies (63, 125, 500, 1000, 2000, 4000 and 8000 Hz) was 70, 71, 72, 52, 53, 56, 47 and 39 dBA respectively. To ensure that individuals are exposed to the desired level (65 dBA), the noise level was measured for an hour in the room, and finally, the noise generating system played and the level was set at 65 dBA. After exposing participants to the noise, they were asked to complete questionnaires of noise sensitivity, noise Annoyance, Loudness perception, and demographic information. The background and demographic information questionnaire were used in order to obtain personal information such as age, sex, marital status, and the level of awareness of the harmful effects of the noise.

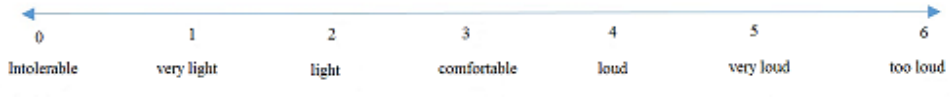

Figure 1. The scale of perceiving noise loudness

For the evaluation of noise annoyance, the ISO 15666 approach was used.[22] Students were asked to respond to the questionnaires and express the degree of their annoyance due to the noise in the room (question: during the past hour that you were exposed to the noise, how much were you annoyed?). Respondents expressed their feeling on a scale of zero to ten. According to the ISO 15666, the degree of annoyance categorized into five groups including without Annoyance (0-2), a little Annoyance (2-4), medium Annoyance (4-6), too much Annoyance (6-8) and infinite Annoyance (8 to 10). Noise sensitivity was measured using the Weinstein noise questionnaire (WNSS) whose validity and reliability was approved by Alimohammadi et al. (Cronbach's alpha was 78.0).[23] Weinstein's noise sensitivity scale includes 21 questions with six choices which are scored on the Likert Scale from completely agree (0) to completely disagree (5). The maximum total score of the test is 105, and the higher score shows more sensitivity to the noise. The level of people's perception of noise loudness was measured with questions about the loudness of the noise. Noise perception shows the degree of noise loudness that individuals receive. This loudness is different according to the frequencies even with the equivalent level.[24]

Statistical Analyses

In order to investigate the association between noise perception and annoyance with noise sensitivity and demographic variables, concerning the non-normality of the data, the Mann-Whitney test was used. We compared the mean of noise perception and Annoyance among the two-state variables. Kruskal-Wallis test was used to assess the relationship between noise perception and Annoyance with variables consisting of three groups. To investigate the interaction between variables (sensitivity and awareness of the harmful effects of noise) on response variables, multivariate analysis of variance MANOVA was used.

Results

In this study, 80 undergraduate and postgraduate students of Mazandaran University of Medical Sciences participated. The mean and standard deviation of noise sensitivity were 55.5 and 4.8, respectively. The minimum and maximum scores for noise sensitivity were 46 and 68, respectively. Percentiles of 25 and 75 for noise sensitivity were 53 and 59 respectively. Accordingly, noise sensitivity was classified into three groups with a score less than the 25 percentile, a score between 25 and 75, and the scores higher than 75 percentile, respectively, for people with low, moderate and high noise sensitivity. Thus, 22 students (22.5%) had low sensitivity of 38 (47%) had moderate sensitivity, and 20 (25%) had high sensitivity. The mean (SD) of the noise sensitivity in low, moderate and high sensitivity groups were 25.2(1.6), 55.7(1.5), and 61.6(2.2), respectively. Moreover, the mean (SD) of the age of the subjects in the groups with low, moderate and high sensitivity was 25.2(1.6), 25.86(1.4) and, 25.7(1.7) respectively. Table 1 shows descriptive statistics on other variables according to the noise sensitivity of participants.

Table 1. Frequency of participants in the study according to their noise sensitivity (n=80)

	Noise sensitivity		
	low	moderate	high
Educational			
Undergraduate	13(59.1)	14(36.8)	8(40)
Postgraduate	9(40.9)	24(63.2)	12(60)
Marital status			
Single	10(45.5)	12(31.6)	9(45)
Married	12(54.5)	26(68.4)	11(55)
Sex			
Female	11(50)	20(52.6)	9(40.9)
Male	11(50)	18(47.4)	11(55)
Awareness			
Low	11(50)	6(15.8)	0 (0)
Moderate	9(40.9)	20(52.6)	6(30)
High	2(9.1)	12(31.6)	14(70)

Table 2. Investigating the relationship of noise perception and annoyance with noise sensitivity and demographic and contextual variables

		Number of people	Noise perception	P-Value	Noise annoyance	P-Value
Noise sensitivity	Low	22	3.6(0.7)	0.001*	7.8(0.7)	0.001*
	Moderate	38	4.1(0.7)		8.4(0.8)	
	High	20	5.5(0.9)		9.3(0.6)	
Educational level	Undergraduate	35	4.2(1.1)	0.24	8.3(0.8)	0.26
	Postgraduate	45	4.4(1.2)		8.6(1.1)	
Marital status	Single	31	4.3(1.1)	0.85	8.3(1.1)	0.25
	Married	49	4.3(1.0)		8.5(1.1)	
sex	Woman	40	4.2(1.1)	0.45	8.4(0.9)	0.53
	Man	40	4.4(1.1)		8.5(1.9)	
Awareness of the harmful effects of noise	Low	17	3.8(0.7)	0.001*	7.9(0.6)	0.001*
	Moderate	35	4.0(0.9)		8.3(0.9)	
	High	28	5.1(1.0)		9.0(0.8)	

* Significance at error level of 5 percent

Based on the results of Table 2, the mean (SD) of noise annoyance in low, moderate and high sensitive groups were 7.8(0.7), 8.4(0.8), and 9.3(0.6) respectively. Also, the noise perception has a mean (SD) of 3.6(0.7), 4.1(0.7), and 5.5(0.9) respectively, in subjects with low, moderate and high sensitivity. The results of Mann-Whitney and Kruskal-Wallis tests showed that noise perception and annoyance were not related to gender, marital status, and educational level. However, there was a significant relationship with noise sensitivity and awareness of the harmful effects of noise.

Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root tests showed significant values for noise sensitivity (values for all four tests were 0/001). Also, the results of three Pillai traces, Wilkes' Lambda, Hotelling's Trace were not significant for knowledge about the harmful effects of noise (its values were 0.105 for all three tests), but the largest square root test showed significant values (0.036). The results of the MANOVA test in Table 3 show that noise sensitivity has a significant effect on both response variables. Also, higher knowledge about the harmful effects of noise only affects noise perception. In general, the interaction of the two variables was not significant on any of the responses.

Table3. Results of the interpersonal effects of MANCOVA test

	sum of squares	mean root squared	DF	mean square	F	P-Value
Revised model	Noise annoyance	24.68[a]	7	2.53	6.69	0.001*
	Noise annoyance	48.97[b]	7	6.99	13.36	0.001*
Intercept	Noise annoyance	3898.82	1	3898.82	7402.46	0.001*
	Noise perception	1016.59	1	1016.59	1941.83	0.001*
Awareness of the harmful effects of noise	Noise annoyance	1.93	2	0.96	1.83	0.167
	Noise perception	3.49	2	1.74	3.34	0.041*
Noise sensitivity	Noise annoyance	7.81	2	3.90	7.41	0.001*
	Noise perception	18.46	2	9.23	17.63	0.001*
Noise sensitivity *awareness of the harmful effects of noise	Noise annoyance	0.84	3	28.0	0.53	0.662
	Noise perception	1.47	3	0.49	0.93	0.427
Error	Noise annoyance	37.92	72	0.52		
	Noise perception	37.69	72	0.53		
Total	Noise annoyance	5793.41	80			
	Noise perception	1583.12	80			
Total score	Noise annoyance	62.60	79			
	Noise perception	86.67	79			

R^2= 0.36 [a]
R^2= 0.46 [b]

Discussion

This study aimed to investigate the relationship between noise annoyance and perception with noise sensitivity among students. Many studies have considered the noise sensitivity as an intermediary factor for causing noise annoyance.[20] The findings of Monazam and colleagues showed that noise, in addition to the direct effect on annoyance, indirectly and through noise, sensitivity causes annoyance as well.[15] According to the results of this study, noise annoyance and perception have a significant relationship with noise sensitivity. In other words, the average score of annoyance and perception in the group with high sensitivity is higher than in other groups. This result is in line with the results of other studies by the researchers.[15, 25, 26] In many studies, noise sensitivity was the main cause of annoyance, but some researchers have argued that those who are sensitive to noise are also sensitive to other environmental stimuli. Therefore, it cannot be concluded that the main cause of noise annoyance is only noise and noise sensitivity. This study, by removing other interfering factors, in a lab, investigated the relationship between sensitivity and annoyance. The results of this study showed that noise sensitivity has a significant effect on annoyance and noise perception. In justifying this, it can be stated that noise-sensitive individuals have a higher level of noise perception on an equivalent level of exposure.

We found that those with high sensitivity have more noise perception. Regardless of all the variables that affect the noise annoyance, it's reasonable that people who perceive the noise more loudly will be more annoyed.[27] This effect is especially more perceptible for low-frequency noise that has the same impact nature.[5, 27] In most studies, to investigate the relationship between noise sensitivity and noise annoyance the physical noise quantities, such as noise pressure levels, have been used. Noise perception reflects the mental exposure of the individual with the noise level. Indeed, not only the noise perception is based on the physical characteristics of noise, but it is also a function of personality traits and individual attitudes.[25, 28] Wardman et al. argued that noise perception is predictable by noise sensitivity.[29] The findings of Wardman et al. confirm the effect of noise sensitivity on noise perception.

As mentioned before, attitude toward noise is one of the determinants of noise perception and noise annoyance.[30] In this study, the level of people's knowledge of the harmful effects of noise also had a significant relationship with noise perception and annoyance. Awareness of the harmful effects of noise is a prerequisite for people's attitude to noise. Findings of this study showed that with increasing awareness of people, the level of noise perception and annoyance increases significantly. In the study of Aucun et al., awareness of the noise hazards for health and attitudinal variables increased noise perception and noise sensitivity.[25] Croesen et al. also stated that in addition to exposure to noise which causes annoyance, people's attitudes toward noise and fear of potential dangers of noise is an important cause of annoyance.[30]

In general, the results of this study indicate that not only the physical quantity of noise causes discomfort but also individual characteristics such as sensitivity can be one of the main causes of annoyance. The results of this study and other studies show that noise perception and sensitivity increase the reaction of individuals to the noise. Also, people's attitude towards noise source and awareness of noise dangers for their health is a factor in increasing the reactivity and sensitivity of people to noise and thus causing annoyance in people exposed to noise.

Although the results of this study indicated a positive and significant association between noise sensitivity with noise annoyance and noise perception, the results could not be generalized to all age groups, as the study was conducted among the

healthy population of 20-30 years old students. Due to the fact that in this study qualitative characteristics of noise such as pitch, sharpness, oscillatory range as well as individual characteristics of people such as health status, personality, etc. are not considered, it is recommended that in future studies, researchers consider these variables.

Conflict of interest

There is no conflict of interest.

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