2008-5435/14/63-209-214
INTERNATIONAL JOURNAL OF OCCUPATIONAL HYGIENE

IJOH 7: 209-214, 2015

ORIGINAL ARTICLE

Effects of Noise and Whole Body Vibration on Individual's Mental Performance

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Received November 01, 2015; Revised November 25, 2015; Accepted December 01, 2015

This paper is available on-line at *http://ijoh.tums.ac.ir*

ABSTRACT

Noise and vibration are the common problems in industrialized countries which can affect individual's job performance. The present study aimed to investigate the combination of the whole body vibration and the noise and their effects on the students' mental performance in the laboratory setting. Twenty male students of Tehran University of Medical Sciences, Tehran, Iran were randomly selected to participate in this experiment. Each participant attended in a test consists of 9 stages through the single exposure to the low frequency noise with two sound pressure levels of 75dB and 85dB and two vibration modes with 0.8 m/s^2 and 1.1 m/s^2 acceleration. In addition, the combination of the exposure with variable noise and vibration were tested. The control mode that was included the combination of the background noise (35dB) and vibration was studied. Finally, this study examined the relationship between student cognitive functions and exposure with noise as well as whole body vibration in shallow, intermediate and deep level by mathematical calculation test. The results showed that at shallow level, the whole body vibration, the noise as well as their interactions did not affect the mental performance of student. However, in intermediate and deep levels, the differences are statistically significant. Noise and vibration are two affecting factors over individuals' mental performance. The amounts of exposure to these variables are crucial. Therefore doing activities with more complex mental tasks require lower levels of physical stressors such as noise and vibration in the environment in order to reduce the error rates in the work.

KEYWORDS: *Noise, Whole body vibration, Mental performance*

INTRODUCTION

Noise is one of the most important harmful job factors in workplaces. About 600 million workers are exposed to unpleasant industrial noise worldwide [1]. Noise has various harmful effects on humans, such as damage to hearing system, interfere with conversation, physiological and psychological effects such as persecutors and individual's well-being reduction [2]. In addition, technology advancement and the need to high speed and more powerful industrial machinery, produce too much mechanical movements and vibration in components.

Hence, vibration is another consequence of industrial development which can be seen in combination with noise in the most business environments, can be the initiator of the noise or in some cases can even resonant the noise [3]. According to the US statistics report, more than

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seven million workers are exposed to the whole body vibration and one million workers are exposed to the hand-arm vibration [4].

Noise is known as a direct influencing factor over mental disorders which can degrade the safety level and increase the probability of work's errors. One of the major causes of accidents is the loss of mental function caused by noise [5]. The attentive functions are significantly affected by environmental conditions. The environment can cause distraction; consequently, can increase the need to focus on work. Noise is one of these environmental factors which require paying more attention. Noise reduces the accuracy in brain activities and the lack of coordination in intellectual tasks and understanding the contents and this has been confirmed in some studies [6-7]. This lack of coordination and the lack of precision and distraction are more evident especially in the context of problem solving tasks and understanding that neurophysiologic changes is expressed as a reason for this subject by some researchers [8-9]. Noise is much more annoying in intellectual works than physical works [10]. When sound pressure level was higher than 90dB, trying to maintain in consciousness state was increased [11]. On the other hand, many workers, especially light and heavy vehicles' drivers expose to the whole body vibrating equipment which can cause fatigue and really affected stress and human performance in workplaces [11-13].

Regarding to the importance of these two issues and the lack of conducted researches in the field of combined whole body noise and vibration effects on mental performance of individuals, we decided to investigate the combined effects of these two variables on mental performance in a laboratory setting.

MATERIALS AND METHODS

Analysis method: The study was carried out in the Physical Factors Lab in the School of Public Health, Tehran University of Medical Sciences and subjects were students from the same university. The number of samples was estimated as it is shown in Equation 1. Applying the standard deviation gained 2.07 for the study which at the significant level of α=0.05, statistic power β= 20%, and taking into account the size of sample d=1.35, the sample size was estimated as 18. To examine the relation of combination of noise and vibration precisely and to prevent losing the cases, the sample size was extended to 20.

$$n = \frac{S^2\,(Z_{1-\alpha/2}+Z_{1-\beta})^2}{d^2} \qquad \textbf{(\textit{Equation 1})}$$

$$\frac{(2.07)^2\,(1.96+0.84)^2}{(1.35)^2} = 18.41$$

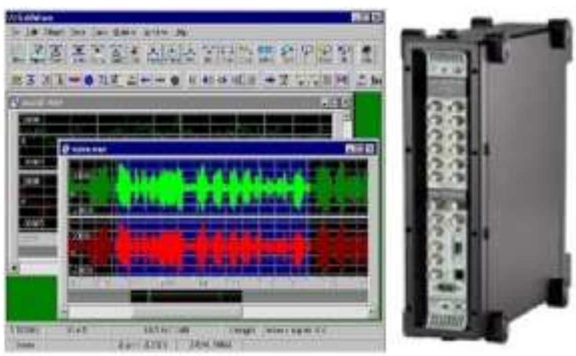
Inclusion criteria were the males aged between 20 and 30 years old, without history of hearing problems, and neither visual problems nor sleep difficulty. The participants were selected randomly from available community. They were participated in the tests, after filling the informed consent form.

Characteristics of the testing environment: The study was carried out in a Room with 3.8×2.5×2.8 meters dimensions without any windows. The walls were ceramic with white color and the ceiling was tile and white. The desk height was about 0.9 meters from the ground level.

In order to record the different stages of work, at the same time to prevent intervention of the researchers in the test, all stages of the test, were performed without the present of researchers in a test room. A closed-circuit television was used in a way that participants were unaware of it and data transferred from the camera to the computer in a room near the testing room and were evaluated by researchers.

The experiments started by broadcasting a warning signal for participants and the end time for the test were alarmed using a stopwatch.

Experimental settings for testing exposure to industrial noise: The source of noise applied was a recorded noise produced from a household appliances that were recorded by pulse application at the hearing height and at the horizontal distance to the source which is similar to the location of workers in workplaces (Fig.1. a). A computer and two pioneer speakers were used in order to confront the sample participants with the recorded noise. Speakers were placed at the one meter distance height on two sides of the test table. Statistical analysis showed a high correlation between the frequency of the recorded sound in industry and the released sound in the laboratory. Released audio sound was converted to the industrial time-varying sound quality by using Gold wave (Fig.1. b). Equivalent level B&K 2236 model sound level meter was used for measuring and complying frequency analyses.



a b

Fig.1. a) Sound recording device (v6.15). b) Sound editing software
(PULSE Multi-analyzer System Listen v12-Type 3560)

Experimental settings for testing exposure to whole-body vibration: A vibration simulator was used which produced vibration by generating sheets in three axes x, y and z in different frequencies and various intensities. Vibration generator was attached to the chair by a metal pillar. In this study, a comfortable chair produced by Peugeot car company with angle adjustment in backrest were applied to resolve the possible inconvenience resulting from embedding vibration generating apparatus and the increasing of the height of the chair. In addition, a footrest made of chipboard was used which could be used depends on (Fig. 2).

The vibration produced by the generator transferred to the seat which were set for sine wave sat frequencies between 3-7 Hz and 0.8 and 1.1 m/s^2 intensity To ensure the calibration of the vibration simulator, the whole-body vibration tester, 2512 model was used which was manufactured by B&K company.

Fig.2. Whole body vibration simulators

Data recorder tools: To determine demographic data of samples, a checklist was used by researchers designed according to previous studies that included two parts (Part I: General information such as age, educational level, marital status and part 2: the hearing status, vision systems status, smoking, drugs as well as sleep status in the last 24 h). Demographic data checklist was completed by participants before starting the experiment. Individuals who did not pass the inclusion criteria were excluded from the study. A standard mathematical test was used to evaluate the individuals' mental performance in whole body vibration and noise exposure as well as simultaneous effects of these two variables.

This standard mathematical test is a written test splitting to15two-digit number that one of the numbers is6, 7, 8 or 9 and calculated outputs are two decimal numbers. Deep mental process is expressed based on the number of calculated correct digits. Mental performance was measured base on the response time and the number of correct answers. In the math test, the correct digit in calculations indicates mental operations at the shallow range, the first digit after the decimal indicates mental operations in the middle range and the second digit after the decimal indicates mental operations at the deep range [14-16]. Participants before testing received sufficient information about the experiment procedure.

In order to evaluate noise effects, three modes were applied consisting, low frequency variable sound in 75dB and 85dB levels with background noise (35dB). The whole body vibration were produced in three modes, without vibration as well as vibration with acceleration 0.8 m/s^2 and 1.1 m/s^2, simultaneously, participants were participated 9 times in math test and among different exposure scenarios sufficient rest were given to them. Finally, SPSS version 20 (Chicago, IL, USA) was used in order to analyze and to assess the data.

Table 1. Comparison of mean testing time in single exposure and the combination of a noise variable and the whole body vibration

Exposure modes	Average testing time (Second)	Standard deviation	*P*-value
75dB*0m/s^2	379.10	8.48	
85dB*0m/s^2	391.33	7.57	0.001
35dB*0m/s^2	326.05	52.15	
35dB*0.8m/s^2	379.61	6.73	
35dB*1.1m/s^2	394.75	6.77	0.001
75dB*0.8m/s^2	394.10	33.54	
75dB*1.1m/s^2	410.15	26.91	
85dB*0.8m/s^2	395.90	53.91	0.057
85dB*1.1m/s^2	429.30	41.64	

RESULTS

Subjects were selected among male with an average age of 26.6±1.6 year. Each participant was tested in 9 different exposure modes to time-varying noise and the whole body vibration parameters. The mathematical test and the impact of variables on the testing time as well as the mental function at the shallow, middle and deep level was studied.

One-way ANOVA test results (Table 1) showed that increasing the noise level and the whole body vibration acceleration in single exposure with any of the variables caused statistically significant increase ($P<0.05$) in the testing time. The results of two-way ANOVA in combining exposure with assessing variables (Table 2), showed the effect of each noise level on the test time does not depend on the whole body vibration's acceleration ($P>0.05$). The test duration in without vibration and background noise was seen 35db.

The two-way ANOVA's results showed that the single and the combined exposure to time-varying the noise and the whole body vibration variables did not affect over mental function (P>.0.05). In the shallow range; however, it was effective in two middle levels and deep level (P<0.05).

Table 2. The single and the mutual effect of sound factors and whole body vibration on mental performance in three levels of shallow, middle and deep span

Mental performance	Exposure modes	Mean	Standard deviation	P-value
Shallow range	35dB*0m/s^2	13.15	1.3	0.109
	75dB*0m/s^2	12.45	1.7	
	85dB*0m/s^2	12.65	1.8	
	35dB*0.8m/s^2	12.85	1.5	0.550
	35dB*1.1m/s^2	12.70	1.6	
	75dB*0.8m/s^2	12.55	1.8	
	75dB*1.1m/s^2	12.65	1.5	0.803
	85dB*0.8m/s^2	12.20	1.5	
	85dB*1.1m/s^2	11.95	2.0	
Middle range	35dB*0m/s^2	26.10	3.0	P<0.001
	75dB*0m/s^2	24.90	4.0	
	85dB*0m/s^2	25.40	3.4	
	35dB*0.8m/s^2	25.30	3.2	P<0.001
	35dB*1.1m/s^2	25.80	3.5	
	75dB*0.8m/s^2	23.50	3.4	
	75dB*1.1m/s^2	21.50	2.7	0.045
	85dB*0.8m/s^2	21.90	4.3	
	85dB*1.1m/s^2	20.70	2.9	
Deep range	35dB*0m/s^2	34.95	6.9	P<0.001
	75dB*0m/s^2	31.20	7.4	
	85dB*0m/s^2	32.25	7.4	
	35dB*0.8m/s^2	35.85	6.3	P<0.001
	35dB*1.1m/s^2	32.85	7.2	
	75dB*0.8m/s^2	29.10	7.6	
	75dB*1.1m/s^2	24.30	6.8	0.049
	85dB*0.8m/s^2	27.00	7.5	
	85dB*1.1m/s^2	20.70	4.0	

DISCUSSION

The results of this study revealed that noise has a significant effect on the math testing time. In other words, exposure to higher noise significantly increases the testing time. Also, examining the effects of whole body vibration on the testing time in this study showed that by increasing vibration acceleration, the reaction time increased. The results of data analysis showed that two variables that are the interaction at different sound levels and vibration acceleration variable were not statistically significant in terms of average testing time.

Not having any significance effect of the sound interaction and the whole body vibration over computational efficiency on the shallow level can be explained by this reasoning that the effect of high levels of sound on shallow computing performance does not depend on accelerative vibration or in other words, increasing the vibration cannot have a synergistic effect on the negative impact of sound level and vice versa. Assessment of vibration effect on drivers' hearing reaction in long-term driving showed that with increasing the exposure duration to vibration, auditory reaction time increased; although this difference was not statistically significant [17]. The combined effects of poor posture and the vibration exposure increased the person's reaction time [18]. The whole body vibration did not cause statistically significant effect on the reaction time [19] which is different form obtained data in the present study.

In addition, our study showed that the time-varying sound level does not significant effect on the mental function at the shallow level but impacts on the middle and the deep level of mental performance. The results also illustrated that increasing the amount of vibration did not have significant effect on the mental performance mean of the subjects at shallow level that could be because of simplicity of the math test in this level which does not require a high intellectual activity. Examining the effect of combined exposure to sound and the whole body vibration on mental function at the shallow range also showed that this relationship was not statistically significant.

Previous Researches provided conflicting results regarding to the sound effects on mental performance during performing the mathematical calculations. Increasing the sound pressure level reduced efficiency and accuracy of intellectual activities while increased the error rates in intellectual activities [20]. The effect of noise between 50dB to 110dB on decreasing the mental performance is reported [21-22]. Noise does not affect mental function [23]. Increasing the noise would improve the speed and the accuracy in tests related to mathematical mental processing [24-25]. Existing differences in the results of various studies may be due to the individual's different sensitivity to the sound in different studies. The sound type has significant effect on problem solving process and the temporary and intermittent sound have the maximum affects [26]. The sound and vibration have a negative impact on the reading capabilities. However, the impact of vibration and noise on the human performance was not significant [27].

The results of the tests also showed that the whole body vibration has a significant effect on mental performance of subjects at the middle and deep level so by increasing the vibration, the computing efficiency reduced. The results are compatible with previous study that showed that by increasing vibration, the number of incorrect responses increased [19], while it is different from Hancock and et al. in which they stated that the vibration intensity did not influenced mental performance in reading activity of participants [28].

CONCLUSION

The increase in time-varying noise level and the whole body vibration increases the response time as a result of necessity for longer required time to do the math calculation.

Increase in the noise level and the whole body vibration acceleration do not affect over the mental performance and operation at shallow level. It means by increasing or decreasing of the whole body vibration and noise, correct answers to digit of math divisions doesn't change. While it can have significant effect on mental performance of participants in both mid-deep levels, so, by increasing the whole body vibration and the noise, the number of correct answers of first and second decimal math divisions decreased. Therefore it is recommended that in environments which require detailed mental activities, some measures will be performed to reduce the noise and vibration exposure.

ACKNOWLEDGMENTS

This research was funded by Research Deputy of Tehran University of Medical Sciences with the approved number (920113222103). The authors would like to appreciate the physical factors laboratory experts in Tehran University of Medical Sciences. The authors declare that there is no conflict of interests.

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