Correlation of noise level exposure on the reaction time of workers at a manufacturing company in Bandung, Indonesia

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Abstrak

Latar Belakang: *Para pekerja sering kali terpaksa berhadapan dengan kebisingan tinggi ditempat kerja. Kebisingan mengganggu perhatian yang diperlukan terus-menerus dan menurunkan produktivitas kerja, oleh sebab itu pekerja yang melakukan pengamatan dan pengawasan terhadap satu proses produksi atau hasilnya, dapat membuat kesalahan akibat dari terganggunya konsentrasi dan kurang fokusnya perhatian. Pada penelitian ini dilakukan pengukuran waktu reaksi cahaya dan suara untuk menilai fokus perhatian/konsentrasi.*

Metode: *Studi analitik dengan desain komparatif cross sectional. Penelitian ini dilakukan pada perusahaan manufaktur yang memproduksi benang nylon sintetik. Membandingkan rerata selisih waktu reaksi cahaya dan suara sebelum dan setelah bekerja dengan pajanan kebisingan pada kelompok subjek yang bekerja pada intensitas kebisingan di atas NAB (area braiding) dibandingkan dengan yang di bawah NAB (area waring), dimana sebelumnya dilakukan pengukuran intensitas tingkat kebisingan di kedua area tersebut.*

Hasil Penelitian: *Perbedaan bermakna waktu reaksi cahaya yang melambat pada subjek yang bekerja dengan pajanan kebisingan di atas NAB sebelum dan setelah bekerja (p=0.007), namun tidak dengan waktu reaksi suara. Tidak terdapat perbedaan bermakna waktu reaksi cahaya dan suara pada subjek yang bekerja dengan pajanan kebisingan di bawah NAB sebelum dan setelah bekerja. Terdapat perbedaan bermakna rerata selisih waktu reaksi cahaya yang melambat pada subjek yang bekerja pada pajanan kebisingan di atas NAB dengan di bawah NAB, p=0,017, namun tidak bermakna terhadap rerata selisih waktu reaksi suara.*

Kesimpulan: *Terdapat perbedaan rerata selisih waktu reaksi cahaya pada pekerja yang bekerja dengan pajanan kebisingan di atas NAB dibandingkan dengan pekerja yang bekerja dengan pajanan kebisingan di bawah NAB, sehingga tingkat intensitas kebisingan tinggi (di atas NAB) mempengaruhi waktu reaksi cahaya dan menjadi lebih lambat.* ***(Health Science Journal of Indonesia 2020;11(1):38-44)***

Kata Kunci: *waktu reaksi cahaya; waktu reaksi suara; kebisingan*

Abstract

Background: Workers are often exposed to high noise level at their workplaces. Noise can disrupt the worker's concentration and focus and in the end, may cause lower productivity. Thus, workers whose main job descriptions are to supervise workflow from one phase to another are prone to mistakes due to the loss of concentration and focus. In this research, we used reaction timer with light and sound stimuli to assess attention or concentration.

Methods: The study was an analytical study with comparative cross sectional design, comparing a mean difference between light and sound reaction time before and after work. This research was conducted at a manufacturing company that produces synthetic nylon fibers. The subjects were divided into two groups; the workers with noise intensity above TLV (braiding's area) and with noise intensity below TLV (waring's area). Prior to the study, the research has measured the intensity of the noise level in the workplace area.

Result: A significant difference was found in the light's reaction time who work with noise exposure above TLV (p= 0.007) and it was found to be slower after work with the workers who are exposed to noise above TLV. There was also a significant mean difference for the light's reaction time between the above TLV noise group and below TLV noise group (p = 0.017). There was no significant difference in sound reaction time.

Conclusion: There was a significant mean difference in light reaction time for the workers who work with noise exposure above TLV compare with the workers who work in below TLV, so that high intensity of noise level is found to affect and decrease the light reaction time of the workers. ***(Health Science Journal of Indonesia 2020;11(1):38-44)***

Keywords: light's reaction time, sound's reaction time, noise.

Workers are often exposed to high noise level at their workplaces.[1] Noise can disrupt the worker's concentration and focus and in the end, may cause lower productivity. Thus workers whose main job descriptions are to supervise workflow from one phase to another are prone to make mistakes due to the loss of concentration and focus.[2] Level of concentration reflects cognitive performance.[3] Exhaustion can decrease work capacity and work endurance that is signified by a decrease in workers' motivation and their activity levels thus decreasing their work productivity.[4] Work exhaustion can decrease workers' reaction time.[5,6]

In 2015, Hansen et al in their Norwegian study, evaluated 87 marines who were assigned at 4 different locations with various noise decibels <72,6 dB, 72,6 – 77,0 dB, 77,1 – 85,2 dB, and >85,2 Db (the study used personal noise dosimeter). After 4 hours (7.5 $\pm$ 2.5 hours; with range of 4.3 – 9.5 hours), the subjects which were exposed to noise performed a cognitive function test (visual attention and time reaction). The study concluded that there was a significant decrease in time reaction and visual attention in the subjects that were exposed to noise >82.5 dB.[7]

This company has approximately 300 employees including office staff. The main productions are waring process ("waring") which produces fishing net, and braiding process ("braiding") which produces fishing lines. Fishing lines which are produced in this manufacture is second best quality in the world nowadays. All that process was worked continuously for 24 hours a day and divided into two work shifts. In the preliminary study, the author found that the workers in the braiding area complained of tiredness or exhaustion, lack work concentration, error tendencies when following orders from their supervisors at the braiding area, work accidents like head trauma with machine body, finger crushed by the machine at waring area. In braiding and waring area, workers do not always use their hearing protective equipment.

This study investigated the correlation of noise level exposure on the reaction time of workers at a manufacturing company in Bandung, to know whether a decrease speed of light and sound's reaction time before and after work with the noise exposure compared at braiding and waring area.

METHODS

This study was an analytical cross sectional comparative design. This study compared reaction time between a group of respondents who work at noise exposure above TLV and below TLV. TLV becoming the boundary in this study for 12 hours of work in noise that was 83,2 dBA where the formula was obtained from ACGIH (American Conference of Governmental Industrial Hygienist).[8,9]

The research was started in September 2017 and samplings were taken until November 2017.

The inclusive criteria were workers who work with noise in the production process and work continuously with noise exposure in their workplace for at least four hours a day. The exclusion criteria were workers who have sickness (URTI and pain at their hands); workers who consume alcohol, antihistamine and tranquilizer drugs before the study is started.

Before this study started, the author explained to the subjects about all the procedurs and measured noise intensity at braiding and waring area at four different points in each area with a sound level meter from Balai K3 Bandung which has been calibrated and measured by the certified officer. Questionnaires were filled by all the subject about age, education level, right or left handed, caffeine consumption, period of work and time traveling to the workplace and sleep quality before work using a questionnaire from PSQI (Pittsburg Sleep Quality Index) which has been validated in Bahasa.[10]

Reaction time was measured with a reaction timer Lakassidaya type of SLS-L77 product of 2016 and has been calibrated. This tool has obtained a rightful authority patent certification in Indonesian occupational medicine. Reaction time was measured before and then 4 hours after work continuously with noise exposure for every worker. Every subjects were tested with light (yellow beam) and sound's (beep) stimulus and tested 20 times each of stimulus, measurements were taken by the list at point six until point fifteen then be averaged.[3] The reason was, at first until the fifth measurement is supposed in adaptation process with that tool, and at sixteenth until twentieth measurement are supposed in tired condition.[11,12] All the subject was obtained by consecutive's technic sampling.

Statistic analysis used SPSS version 20. The author has obtained approval and permission from the company to conduct the research in the company. Research has also been approved by Medical Research Ethics Commission of the Faculty of Medicine, Universitas Indonesia, Number 1019/ UN2.F1/ETIK/2017.

RESULTS

Table 1. The Distributions Table Based on Relation Between Characteristic and Variables

Variables	Braiding area (Above TLV) n=47	Waring area (Below TLV) n=47	p-value	n=94	Persentage (%)
Ages (years)					
median (min – max)	22.0 (17-48)	27.0 (16-42)	<0.001*	94	
Education level					
Basic (SD, SMP)	14 (28,57%)	35 (71,43%)	<0.001#	49	100
Middle-High (SMA/SMK, Akademi, PT)	33 (73,33%)	12 (26,67%)		45	100
Sleep Quality (Total score from PSQI)					
≤5 (good)	22 (40%)	33 (60%)	0.036#	55	100
6-21 (bad/poor)	25 (64,10%)	14 (35,90%)		39	100
Left/Right handed					
Right	45 (50%)	45 (50%)	1.000	90	100
Left	2 (50%)	2 (50%)		4	100
Caffeine consumption					
No Consumption in latest 12 hour	30 (61,22%)	19 (38,78%)	0.039#	49	100
Consumption in latest 12 hour	17 (37,78%)	28 (62,22%)		45	100
Period of work					
<3 years	38 (84,45%)	7 (15,55%)	<0.001#	45	100
≥3 years	9 (18,36%)	40 (81,64%)		49	100
Time travelling to the workplace					
<30 minutes	41 (52,56%)	37 (47,44%)	0.410	78	100
≥30 minutes	6 (37,50%)	10 (62,50%)		16	100

* tested by unpaired T-Test.; # tested by chi square

In table 1, the authors compared each category at the workplace which was divided into noise intensity above TLV (braiding area) and below TLV (waring area). There are significant differences of age with median value of age in braiding area which was 22 years old and 27 years old in waring's area. There are significant differences proportion of characteristics in education level, sleep quality, caffeine consumption, and period of work.

TLV for 12 hour of noise intensity has been measured for 83,2 dBA according to ACGIH. From the table 2, braiding area has four points measurements with the noise intensity above TLV for 12 hours, in waring area has the noise intensity below TLV for 12 hours.

Table 2. The Result of Noise Intensity Measurement in Braiding and Waring's Area

Location of Measurement	Method	Devices	Units	Result in Braiding's area	Result in Waring's area
Point A	SNI 7231 : 2009	Sound Level Meter	dBA	90,7	79,9
Point B	SNI 7231 : 2009	Sound Level Meter	dBA	92,1	81,4
Point C	SNI 7231 : 2009	Sound Level Meter	dBA	92,0	81,8
Point D	SNI 7231 : 2009	Sound Level Meter	dBA	91,2	78,1

Table 3. Table of difference average light and sound's reaction time before and after work with noise exposure above TLV and below TLV

Above TLV (Braiding Area)*				
Reaction Time	Before work (ms)	After work (ms)	Difference mean of reaction time (ms)	*p-value*
	Median (min-max)	Median (min-max)		
Light	220,13 (156,48 – 301,21)	229,30 (173,16 – 350,24)	18,07	0,007
Sound	191,79 (147,97 – 278,68)	200,41 (152,87 – 295,92)	7,16	0,374
Below TLV (Waring Area)#				
	Mean ± SD	Mean ± SD		
Light	212,69 ± 41,35	213,78 ± 29,48	1,98	0,412
Sound	192,95 ± 33,59	191,47 ± 26,25	-1,47	0,376

* tested with Wilcoxon: # tested with paired T-Test

In table 3, a median for light reaction time before work was 220,13 millisecond and after work with noise exposure above TLV was 229,30 millisecond. The average difference of light reaction time was 18,07 millisecond slower after work and the average of these differences is significant with p-value 0,007 for light reaction time before and after work. A median for sound reaction time before work was 191,79 millisecond and after work with noise exposure above TLV was 200,41 millisecond. The average of differences sound reaction time was 7,16 millisecond slower after work and the average of these differences is not significant with p-value 0,374 for sound reaction time before and after work.

A mean value of light reaction time before work was 212,69 millisecond and 213,78 millisecond after work with noise exposure below TLV. The difference mean of light reaction time was 1,98 millisecond slower after work and it was not significant with p value 0,412. A mean value of sound reaction time before work was 192,96 millisecond and 191,47 millisecond after work with noise exposure below TLV. The difference mean of sound reaction time was 1,47 millisecond faster after work and it was not significant with p value 0,376.

Table 4.Table of mean difference light and sound reaction time before and after work with noise exposure above TLV and below TLV

	Above TLV (ms)	Below TLV (ms)	*p-value*
	Mean ± SD	Mean ± SD	
Mean of difference light reaction time	18,07 ± 39,46	1,98 ± 33,14	0,017*
Mean of difference sound reaction time	7,16 ± 41,90	-1,47 ± 32,18	0,133

* tested by unpaired T-Test

Table 4 shows a worker group in braiding area has mean differences for light reaction time which was 18,07 millisecond slower and worker group in waring area has mean differences for light reaction time which was 1,98 millisecond slower. There was a significant difference in the mean differences for light reaction time for noise exposure above TLV compared with the noise exposure below TLV (p=0,017). In table 4, worker group in the braiding area has mean differences for sound reaction time which was 7,16 millisecond slower and workers group in waring area has mean differences for sound reaction time which was 1,47 millisecond faster after work There was a significant difference in the mean differences for sound reaction time for noise exposure above TLV compared with the noise exposure below TLV (p=0,133).

To prevent from the measurement bias, all measurements in table 3 and 4 were measured by researcher's assistant who was trained before by the expert in using calibrated reaction timer and the measurement was also performed on several workers who were not respondents in this research.

DISCUSSIONS

There are significant differences in mean for age, difference of proportion characteristic in education level, sleep quality, caffeine consumption and period of work with noise exposure at braiding and waring area.

There was a significant difference in median of age in workers who work at braiding area and waring area. There is no requirement from this company for the workers in braiding area to be younger than the workers in waring area. Workers in braiding area have never been moved to waring area which has noise intensity below TLV.

There was a correlation between education level and workplaces in braiding and waring area where the most of workers with low education level worked at waring area and workers with middle high education level placed in braiding area. There is no requirement from this company for the workers in braiding area to have a higher education level than the workers in waring area.

There was a correlation between sleep quality and workplaces in braiding and waring area where most of workers with good quality of sleep worked at waring area and they who have poor quality of sleep worked at braiding area. This study did not try to find whether high noise exposure experienced by the workers would affect their sleep quality.

There was a correlation between caffeine consumption and workplaces in braiding and waring area, where most of the workers consuming caffeine worked at waring area. There is no requirement from this company for the workers to consume caffeine before work on both sites.

There was a correlation between the period of work and workplaces in braiding and waring area. Most of the workers in braiding area have period of work

below 3 years and vice versa, workers in waring area have period of work above 3 years. The turnover rate of workers in this company is approximately 3 years. Thus it can be assumed that the workers who work with high noise exposure below 3 years have not accumulated the side effect of the hearing risk.

A significant difference of mean light reaction time before and after work with noise exposure above TLV is in accordance with the research conducted by Hansen et al in Norwegia.[7] This study observed 87 marines assigned at 4 different locations with various noise decibels <72,6 dB, 72,6 – 77,0 dB, 77,1 – 85,2 dB, and >85,2 dB (the study used personal noise dosimeter), it has a significant decrease of time reaction of visual attention in the subjects after 4 hour-exposure with noise >82.5 dB. In this study has measured noise intensity at five points difference in the braiding area with equivalent values above TLV. They can induce tiredness because of high noise exposure that was exposed to the workers continuously for their 12 hour-shift works and all the workers did not use personal protection devices. It is different from the workers working at waring area where the equivalent values were measured below TLV although they have the same workload.

There is no significant difference in mean sound reaction time before and after work with noise exposure above TLV. Based on a study from California Training Institute in 2010, mean of sound reaction time is faster than light reaction time. It is because sound stimuli need approximately 8-10 millisecond to reach the central nerves system in brain while light stimuli need approximately 20-24 milliseconds.[13] That explanation is assumed to happen in this study where the subjects who were given sound stimuli have not too different reaction time between before and after work although their mean reaction time decreased after work with noise exposure. In addition, the subjects who had their reaction time measured 4 hours after work know how to conduct the tests so that there is a psychophysiological process in brain related to motivation, attention, and respond to the stimulus.[14]

There is no significant difference in mean light and sound reaction time before and after work with noise exposure below TLV. Disturbance of cognitive performance can consist of four main components: reading process, recall memory, recognition process, and attention where its component has a strong relation with noise exposure.[15] Noise exposure below TLV is not related with a wary cognitive performance. However based on last study, they can affect the cognitive performance in decreasing ability to comprehend a reading or decreasing short memory function and recognition process.[4,16] In this study, subject's cognitive performance was not measured memory function tests like a study was observed by M.M Haines in London (2001), subjects who work at area where the noise intensity is below TLV were measured by light and sound reaction time with no statistically significant mean differences. In addition, a noise intensity measured was found to be below from TLV. In theory, it is mentioned that high noise level for a long period can induce tiredness and stress.[3,5]

There is a significant the mean difference of light reaction time for the subjects who were work with noise exposure above and below TLV but it is not significant for sound reaction time.

From the preliminary survey, this company does not have a health and safety environment programs such as periodical medical check up, environmental exposure monitoring, engineered machines which emit high noise. These matters can affect the workers for working with the noise exposure continuously 12 hours. In braiding area, the workers became easily tired.

This result has a similarity with the study by Hansen K.I. et al in 2015 which studied the speed of reaction time at Norwegian army who worked with noise intensity above 85,2 dBA compared with them who worked with noise intensity <72,6 dBA, 72,6 – 77,0 dBA, 77,1 – 85,2 dBA, the result showed significant value for attention visual reaction time (mean 380 ms, deviation standard 40).

The study researched by Balakrishnan in India tested reaction times with light stimulus red, green, and yellow. The result showed that yellow light stimulus slower approximately 25 miliseconds compared with red and green light stimulus ($p<0,001$). It was because the time needed to process yellow colour is more complex in central nervus system than the color green and red, so that they need much longer time.[17] In this study, the reaction timer use yellow light stimulus and all the subject was exposed by noise, so that this factor can be assumed as to why the light reaction time in this study become slower. Kahneman in 1973 explained that moderate noise intensity that occurs in a long time continuously can disturb attention and concentrations.[18]

In this study there are no significant mean differences in sound reaction time before and after work for

the subjects who work with noise exposure above and below TLV. On statistical analysis showed no significant difference in mean sound reaction time before and after work with noise exposure both above TLV and below TLV. This explanation can be related to the difference of individual's sound sensitivity where it can be measured with comparing a performance or ability to detect a noise or not. It is usually not related with the quality of hearing. Peoples who have higher sound sensitivity are known have a lack of attention and ability to work compared with them who have lower sound sensitivity. Individual's sound sensitivity is not always related to decreasing work performance and its relation to noise level.[19] It can be related to period of work. The worker's period of work where exposed by noise intensity continuously while working may have accumulation of effects in individual that can affect to reaction time. In this study, the average of worker's turnover rate in braiding area is 3 years, 38 subjects have period of work below 3 years and 9 subjects have period of work above 3 years. It can be assumed that the workers who have period of work below 3 years have not accumulated negative effects from noise exposure related to their hearing physiology that can affect individual's sound sensitivity. According to the study researched by Anggraini in 2006 and Budiyanto in 2010 that investigated a correlation between period of work the workers exposed high noise intensity with subjective complaints who worked with noise intensity in range 86,8 dBA -91,2 dBA and work stress. This study divided period of work. They defined the short period if it was below 6 years, medium period if it was in the range 6-10 years and long period if it was above 10 years. The result shows a significant correlation between period of work between the workers who are exposed to high noise intensity. The subjective complaints coming from the situation are fatigue, lack of focus concentration, uncomfortable feeling of condition at work and work stress.[20,21]

The sound frequency used in reaction timer was within normal threshold that can be heard by human which is 20Hz - 20.000Hz.[2]

In conclusion, in this study, the mean of difference light reaction time before and after work was 18,07 millisecond slower for the workers at braiding area and 1,98 millisecond slower for the workers at waring area, with the difference was statistically significant. The mean difference of sound reaction time before and after work was 7,16 millisecond slower for the workers at braiding area and 1,47 millisecond faster for the workers at waring area, with the difference was not statistically significant. The researcher's suggestion for the workers in braiding area is a recommendation for using hearing protection devices because the workers in this area are found to experience a decrease in reaction time while exposed by high noise intensity during work. Company needs to do an engineering control to reduce the noise level produced by the machines such as installing sound box and sound absorbent material.

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