2008-5435/14/63-33-37
INTERNATIONAL JOURNAL OF OCCUPATIONAL HYGIENE

IJOH 9: 33-37, 2017

ORIGINAL ARTICLE

The Impact of Lighting on Accuracy and Pace of Working among Men Student by Tests of Job Skill Assessment under Experimental Condition

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Received January 07, 2017; Revised January 29, 2017; Accepted February 21, 2017

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

ABSTRACT

Harmful physical factors of workplace including lighting may affect the cognitive performance of human. Therefore, tests of job skill assessment (BATTERY method) were used to conduct this study under experimental condition, with the aim of determining the effect of lighting on the accuracy and pace of working in men. This experimental study was conducted on 29 male students in the climatic chamber under the conditions of mild weather (40% relative humidity and dry bulb temperature of 20 °C) in the laboratory of the School of Public Health, Isfahan, Iran in 2016. Participants took a rest for 10 to 15 min. Then they carried out all tests of job skill assessment (BATTERY method) in 0, 40, 80, and 120 min after beginning. The number of errors (accuracy assessment) and the duration of the test (pace assessment) were recorded. There was a significant difference in the mean values of accuracy and pace in exposure to different intensities of lighting (200, 500, 800, 1500 lux) while carrying out the job skill assessment tests ($P<0.001$). An increase in the intensity of lighting may enhance people's performance and limit unsafe behaviors by increasing the accuracy and pace of working while conducting cognitive activities.

KEYWORDS: *Accuracy of working, Battery, Lighting, Pace of working*

INTRODUCTION

Work-related accidents are among the main causes of disability and mortality around the world [1].

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Based on the ILO's report in 2011, about 337 million occupational accidents occur every year in the world [2]. The analysis of enormous accidents such as Three Mile Island in America, Bhopal in India and

thousands of other examples show that in more than 70% of cases, unsafe behaviors and human errors are considered the major factors of accidents [3-6]. The study on unsafe behaviors in automotive industry indicated that the physical conditions of the workplace including harmful physical and ergonomic factors play the most important role in causing stress [7].

On the other hand, harmful physical factors of workplace may affect staff efficiency, work efficiency and productivity by decreasing the accuracy, pace and the ability to apply the skills [8-9]. Lack of lighting is one of the harmful physical factors, which cause stress in the workplace. Adequate lighting is necessary for a good vision. Deficient or excessive lighting may lead to various problems such as eye tiredness, headache, visual impairment, stare, mental effects and non-visual biological effects such as changes in the circadian secretion, temperature, heartbeat, cortisol secretion and melatonin secretion [10-11]. Lighting can also affect human performances. Suitable lighting usually improves working conditions, enhances the efficiency of human resources and creates a satisfying and comfortable mental condition [12].

On the other hand, the tests of job skill assessment (BATTERY method) are used to measure different people's rehabilitation and their ability to get back to work. This set of tests is used to measure the workers' hand-eye coordination, accuracy, pace of working, motor skills, perception, mental consciousness, two-hand coordination, agility, hand skills and so on [13]. Therefore, the impact of lighting on people's performance and efficiency, people's function had not been studied in Iran by applying the tests of job skill assessment (BATTERY).

This study was conducted in laboratory based on BATTERY method with the aim of determining the impact of lighting on men's accuracy and pace of working.

MATERIALS AND METHODS

This interventional study was conducted on 29 male students of Isfahan University of Medical Sciences, in the laboratory of the School of Public Health, Isfahan, Iran in 2016. Samples of this study were selected randomly.

The inclusion criteria were as follows: the absence of musculoskeletal diseases, the absence of uncorrected poor vision, taking no medication, the absence of infectious diseases and tiredness. Exclusion criteria include tiredness and not participating appropriately in conducting the study. Controlled variations in this study include controlling disturbing noises by conducting the experiment in an acoustic room and controlling the temperature by conducting the experiment under the conditions of mild weather (40% relative humidity and dry bulb temperature of 20 °C) in the climatic chamber. To ensure that the conditions were the same during the experiment, noise was monitored by a (Casella cell 450), and moisture and temperature were monitored by a Casella WBGT (Casella cell microtherm WBGT). Four fluorescent lamps (pars Shahab 200W) with adjustable brightness were also used in order to provide the desired brightness. A Lux meter (TES 1335) was used to measure the amount of light. Inside the chamber, a 70 cm high desk and an ergonomic chair were inserted for the participant to sit.

After preparing the conditions and approving the participants according to the inclusion and exclusion criteria, the aim of the study and its procedures were explained to the participants, and they signed a consent form. Then demographic information of the participants (including age) was recorded by the demographic information questionnaire. Then participants carried out the tests in 4 sessions with 200, 500, 800, and 1500 lux light levels.

In this study, job skill assessment tests (BATTERY method) were used to measure working accuracy and pace. Two tests have used the test of steadiness and two-arm coordination test. The tools used for the test of steadiness include V pieron tremometer and targeting accuracy tremometer. V pieron tremometer contains two metal branches with a metal angle graded in several forms. The participant is to move a metal pen between these angles in a way that it does not touch its sides. The targeting accuracy tremometer contains a metal pen, a flashing light, a timer and a stopwatch. In this method, the participant should push the metal pen into the holes from the largest to the smallest one in sequence, and then take it out. In this test, also the pen's collision with the holes' sides is considered to be a lapse [13-14]. The other test was two-hand coordination test which contains a star pattern, a pen attached to two arms, an error detector device, a flash lighting, a buzzer and patch cords for connection [15-16]. In this test, the participant should use the pen and arms to draw another star between two lines of the given star. He should continuously go through this direction clockwise and counter-clockwise. Any contact with the sides of the star or coming out of it is also a lapse.

After entering the chamber, the participants took a rest for 10 to 15 min so that they could recover their mental fatigue. This process was precipitated by asking the participants to eat some sweet foods. By the examiner's order, the examinees started to accomplish the task while the examiner recorded their errors (accuracy

Published online: March 28, 2017

measurement) and the duration of the test (pace measurement). During this time, the participants gave the job skill assessment test in 4 sessions: at the beginning, 40 min after the beginning, 80 min after the beginning and 120 min after the beginning, respectively. Finally, SPSS 20 software (Chicago, IL, USA) was used to describe and analyze the data.

RESULTS

The mean and standard deviation of the age, relative humidity, and dry temperature have shown in Table 1. The Mean of dry temperature and relative humidity had no meaningful difference during conducting different tests (P>0.05).

Table 1. The mean and standard deviation of the age, relative humidity, and dry temperature

Parameters	Mean	Standard deviation
Age (yr)	24.51	2.30
Relative humidity	40.7	1.8
Dry temperature	21.3	1.1

The mean and the standard deviation of the number of participants' errors in different intensities of lighting during job skill assessment tests including clockwise and counter-clockwise two arm coordination, V pieron test and test of targeting accuracy tremometer, have presented in Table 2 to represent working accuracy after 0, 40, 80 and 120 min from beginning. In addition, the results of the one-way ANOVA with repeated observations indicated that the mean of working accuracy while giving the tests of job skill assessment including clockwise and counter-clockwise two arm coordination, V pieron test and targeting accuracy tremometer test, had a significant difference in exposure to different intensities of lighting (P<0.001). Based on these results, the participants' working accuracy increased meaningfully by increasing the intensity of lighting.

The mean and the standard deviation of the time taken by participants to give the test in exposure to different intensities of lighting have presented in Table 3. As an indicator of pace of working after 0, 40, 80 and 120 min of giving the tests of job skill assessment including clockwise and counter-clockwise two arm coordination, V pieron test and targeting accuracy tremometer test. Moreover, the results of the one-way ANOVA with repeated observations indicated that the Mean of the pace of working in exposure to different intensities of light, had a significant difference while giving the tests of job skill assessment including clockwise and counter-clockwise two-arm coordination, V pieron test and the targeting accuracy tremometer test (P< 0.001). Increasing the lighting intensity leads to a significant increase in the participants' pace of working.

Table 2. The mean and standard deviation of the number of the participants' errors in exposure to different intensities of lighting as an indicator of their working accuracy while giving the tests of job skill assessment

Parameters		The intensity of lighting	Elapsed time				
			0 Standard Deviation ± Mean	40 Standard Deviation ± Mean	80 Standard Deviation ± Mean	120 Standard Deviation ± Mean	Whole Standard Deviation ± Mean
Type of test	Clockwise two arm coordination	200	0.96±1.23	0.79±.97	0.62±0.90	0.79±0.81	0.79±0.39
		500	0.13±0.35	0.34±0.55	0.41±0.62	0.75±0.43	0.41±0.54
		800	0.03±0.18	0.24±0.57	0.37±0.49	0.34±0.48	0.25±0.47
		1500	0.20±0.47	0.10±0.30	0.17±0.38	0.16±0.37	0.16±0.38
	Counter-clockwise two arm coordination	200	0.44±1.05	0.41±0.68	0.79±0.61	0.86±0.91	0.62±0.84
		500	0.20±0.41	0.24±0.43	0.51±0.01	0.37±0.49	0.33±0.49
		800	0.03±0.18	0.27±0.45	0.37±0.49	0.34±0.48	0.25±0.86
		1500	0.03±0/18	0.10±0.30	0.10±0.30	0.06±0.25	0.7±00.26
	V pieron test	200	13.69±3.08	14.31±3.30	14.4±3.21	15.58±3.75	14.57±3.36
		500	11.1±3.13	10.93±2.60	10.93±2.26	12.1±2.80	1.26±2.71
		800	9.17±2.47	8.89±2.91	9.42±1.99	9.75±1.88	9.26±2.07
		1500	7.86±1.78	7.06±1.77	6.72±2.20	6.89±2.19	7.13±2.07
	The test of targeting accuracy tremometer	200	11.86±4.00	12.37±2.24	13.06±3.36	14.25±3.94	12.87±3.76
		500	9.65±2.17	9.68±2.27	10.06±2.75	10.96±2.55	10.09±2.47
		800	8.37±1.89	8.44±1.90	8.62±2.12	9.13±2.23	8.64±2.02
		1500	6.48±2.47	6.55±2.30	5.80±1.67	6.10±2.40	6.25±2.23

Published online: March 28, 2017

Table 3. The mean and standard deviation of the number of the participants' errors in exposure to different intensities of lighting as an indicator of their working accuracy while giving the tests of job skill assessment

	Parameters	Intensity of light	Elapsed time 0	40	80	120	Whole
			Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation
Type of test	Clockwise two arm coordination test	200	56.82±15.42	52.72±11.27	45.11±14.04	41.52±14.07	49.01±14.91
		500	38.96±12.22	3809±14.08	34.97±14.38	35.55±11.03	36.4±012.45
		800	31.45±10.39	31.1±09.59	29.51±9.68	27.55±9.72	27.55±9.72
		1500	27.4±08.52	20.05±10.39	23.39±7.35	23.30±6.97	24.78±8.54
	Counter-clockwise two arm coordination test	200	55.71±11.75	50.86±14.65	41.56±12.84	41.15±13.56	4.32±14.24
		500	38.57±13.39	35.54±11.65	34.27±11.56	33.49±10.73	35.46±11.88
		800	31.58±10.91	31.05±9.91	30.06±10.49	28.07±9.02	28.07±9.12
		1500	26.62±8.22	24.98±7.90	23.05±7.94	2.08±7.27	24.18±7.93
	V pieron test	200	22.48±4.19	24.33±4.74	24.13±4.44	23.46±4.11	23.85±4.34
		500	19.21±4.26	19.17±4.47	18.95±3.90	9.75±4.61	19.27±4.47
		800	18.14±3.32	18.30±3.34	17.97±3.87	17.57±3.25	17.95±3.20
		1500	15.42±3.70	14.81±3.51	15.72±4.05	16.71±13.54	15.51±3.69
	Test of targeting accuracy tremometer	200	38.14±8.59	39.47±7.05	40.38±5.87	37.75±7.24	38.40±8.59
		500	33.36±7.12	31.4±6.92	32.27±5.63	31.66±4.60	32.14±4.61
		800	29.22±5.9	29.8±4.97	28.74±5.09	27.66±4.60	27.66±4.60
		1500	28.09±6.07	29.84±7.31	30.32±6.54	29.4±04.16	29.40±6.50

DISCUSSION

An increase in lighting will enhance the accuracy and pace of working. Temperature as an effective parameter on working pace and accuracy was controlled and had no significant difference in different sessions of conducting the test. Therefore, people's accuracy and pace while conducting the tests were only affected by lighting. The obtained results from all four job skill assessment tests confirm this subject.

Lighting can affect human's functions. It can also lead to a comfortable and mentally satisfying condition [12]. The results of a study shows that physical agents including heat and lighting can affect the occupants' satisfaction in office environment [17]. poor illumination may decrease workers' accuracy, and lead to their tiredness and therefore, make mistakes. In a general illumination of 30 lux, almost all workers suffered from exhaustion [18]. In addition, average visual tasks in an industrial environment indicated that the increase in workers' efficiency after improving the illumination from 300 lux to 500 lux and from 300 lux to 2000 lux was 8 and 20%, respectively [19]. The impacts of lighting (in two levels of 20 lux and 340 lux and four light colors including red, blue, green and white) in computer workstations also indicated that people's best performance was observed in illumination of 340 lux and white and blue light colors [20]. The effects of three temperature levels (17, 21 and 28 °C) and three illumination levels (500, 750 and 1000 lux) were studied on 10 people's error and performance in a laboratory with controlled conditions. The illumination of 1000 lux and temperature of 21 °C improved the workers' health and performance [21]. Moreover, the results of the present study indicated that an increase in the intensity of lighting reduces a number of errors and significantly enhances the pace of working. The best working condition is obtained in an illumination of 1500 lux. In most of the conducted tests, the lapse of time increased the number of errors and pace of working, caused by an increase in people's fatigue while conducting the test. The reason is that after some time, people try to terminate the task as soon as possible. In most of the conducted tests, this increase in the number of errors and pace of working after some time was observable in the illumination of 1500 lux. The reason may be the fact that intense light exposure leads to an increase in melatonin secretion that makes people more conscious and therefore less likely to make mistakes. Adequate lighting can improve human's performance and increase Melatonin secretion [22].

CONCLUSION

An increase in lighting may enhance people's pace and accuracy while conducting cognitive activities. After sometimes, the lighting intensity is increased so that the number of errors might be decreased by enhancing the level of consciousness. Moreover, the tests of job skill assessment (BATTERY) could be used in selecting people who commit less error in unfavorable environmental conditions.

ACKNOWLEDGEMENTS

The authors appreciate the subjects that participated in this study. This article is a result of the MS thesis in Isfahan University of Medical Sciences. The authors declare that there is no conflict of interest.

Published online: March 28, 2017

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Published online: March 28, 2017