International Archives of Health Sciences
Volume 3, Issue 4, Fall 2016
Pages: 157-162
Type: Descriptive Study

Association between Local Illumination and Visual Fatigue among the Research and Development Staffs of Industry

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Abstract

Aims: Work proper lighting means a safe, healthy and comfort conditions for work under a lighting system that includes qualitative and quantitative features. This study aimed to evaluate the surface local lighting of works and eye fatigue among research and development staffs of an automotive industry.

Instrument & Methods: In this descriptive study in Research and Development Department of an automotive industry in 2015, 126 official staffs were selected randomly. A demographic questionnaire and the Visual Fatigue Questionnaire (Persian Version) were used for data gathering. Hagner EC1 Lux-meter was used to measure the local lighting. Data were analyzed by SPSS 20 software, through descriptive statistics.

Findings: The lighting in 382 stations (75.8%) was improper and less than standard. The minimum and maximum intensity of light was between 22.4lux in station 2 (inventory department) and 581lux in station 4 (systems and methods department). The overall intensity in more than 50% units, except the Systems and Methods Department, were less than the standard (300lux). 40.4% of the participants had severe eye fatigue, 28.6% had moderate visual fatigue, 28.6% had low visual fatigue and only 2.4% had no visual fatigue. The average of visual fatigue was 3.50±1.97.

Conclusion: The workplace lighting and the eye fatigue of computer users in the Research and Development Department of the studied automotive industry are not in an acceptable condition.

Keywords
Eyestrain [https://www.ncbi.nlm.nih.gov/mesh/68001248];
Lighting [https://www.ncbi.nlm.nih.gov/mesh/68008029];
Workplace [https://www.ncbi.nlm.nih.gov/mesh/68017132]

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Received: August 21, 2016 Accepted: November 18, 2016 ePublished: December 28, 2016

Introduction

Worldwide workers are exposed to various types of occupational hazards in their workplaces [1-2], hence injuries, diseases and accidents are common. Vision, as the most important sense of human, plays a significant role in people's perception of the environment. An optimal lighting, as one of the pillars of favorable physical conditions of work, improves working conditions and is an important factor for employees' health [3].

Work proper lighting means a safe, healthy and comfort conditions for work under a lighting system that includes qualitative and quantitative features. Any deficiency in one of the features causes physiological effects, e.g. fatigue and visual, hormonal and musculoskeletal disorders. It also affects the efficiency and productivity of the workers [3-5].

Lighting affects the physical and mental conditions and produces fatigue, which may indirectly affects the performance of employees [6]. The results show that the improved ambient lighting increase the efficiency as much as 4.5% [7] and performance up to 3% [8]. This increasing in productivity and performance can be related to visual function and mental improvement [7].

In jobs that employees must employ visual equipment, eye fatigue has a great effect on efficiency and performance [9]. Findings show that proper lighting and an optimal distribution of it in the workplace can reduce visual fatigue and delay the decreasing of staff precision while working [10]. Eye fatigue is defined as a physiological load on the visual system [11]. Too much pressure on eyes can cause irreversible effects [12]. In other words, eye fatigue refers to the visual system decrease. Eye fatigue caused by a frequent and continuous visual system adaptation and the sign of it is known as visual discomfort [11].

In the absence of proper lighting, the person tries to see something with raising eye to things or bringing things to the closest condition, or by increasing the tension in the muscles of the visual system that control eye convergence, to increase the angle of the eye [13, 14]. It seems that the quality and quantity of light can be considered as one of the causes of eye fatigue in work environments.

Widespread use of computers in the past few years and turn it into an irreplaceable necessity in the workplace and life can be associated with a greater incidence of eye complications including eye fatigue. Many studies imply the relationship between eye fatigue and complaints to the use of video terminals and computers [15-18]. Eye fatigue-related symptoms are physiological responses, e.g. headache, eye pressure, irritation, burning, tearing, diplopia, blurred vision and dry eyes, which are known as Computer Vision Syndrome [11, 19, 20].

Moreover, other negative effects of eye fatigue are decreasing in concentration and accuracy at work [19]. Results of the previous studies show that continuous work with video terminals can lead to myopia and its prevalence in individuals [21]. Based on the reliable literatures, some methods have been used for measurement of eye fatigue. Some of them emphasize on the application of laboratory techniques and equipment [22-27], and some have used the questionnaire method [6, 28, 29].

Given that the requirements of digital video terminals and computer systems are common activities in recent decades, as well as the growing trend to more usage of it in many different scientific activities and jobs, the effects of it on human health becomes more tangible every day. Therefore, this study aimed to evaluate the surface local lighting of works and eye fatigue among research and development staffs of an automotive industry.

Instrument & Methods

In this descriptive study in Research and Development Department of an automotive industry of Tehran City, Iran, in 2015, 126 official staffs were selected randomly.

To collect demographic data (age, sex, marital status, education level and work experience), a demographic questionnaire was used.

In order to evaluate the visual fatigue of individuals, authentic version of Visual Fatigue Questionnaire (Persian Version), which contained 15 close questions was used. All answers were designed according to the 10-degree Likert scale. The questionnaire had 4 parts; eye strain (4 items), visual impairment (5 items), ocular surface disorders (3 items) and extra-ocular problems (3 items). The total score was divided to 15 and was compared with the classification

criteria and areas of the visual fatigue. The final score was interpreted as "no fatigue" (≤0.65), "low visual fatigue" (0.66-2.36), "moderate visual fatigue" (2.37-3.88) and "severe eye fatigue" (≥3.89). The validity of the questionnaire was confirmed by some experts and its reliability was measured by Cronbach's alpha coefficient as 0.75 [30]. The questionnaires were completed by individuals as self-report.

EC1 Lux-meter (Hagner; Sweden) was used to measure the local lighting of the surface of 504 randomly selected points in 4 stations of the industry. As the subjects were only in the morning shift, measurements were done in the early morning hours or at least the daylight efficiency and all attempts was made by drawn curtains.

Data were analyzed by SPSS 20 software, through descriptive statistics.

Findings

The mean age of participants was 35.7±6.8 years and the mean of work experience was 10.9±6.9. 73.8% of the participants were male, 69.0% were married and 84.1% had Bachelor degree or above.

The heights of light sources in the stations were between 113 and 250cm and the mean of light source numbers was 3.9±0.5. The mean of light intensity in station 1 to 4 were 240.54±108.57, 244.43±110.90, 213.01±99.05 and 213.05±103.92lux, respectively. The lighting in 382 stations (75.8%) was improper and less than standard. The minimum and maximum intensity of light was between 22.4lux in station 2 (inventory department) and 581lux in station 4 (systems and methods department).

The overall intensity in more than 50% units, except the Systems and Methods Department, were less than the standard (300lux). The lighting of more than 90% of departments including the design (97.61%), programming (93.75%), chassis systems and components (93.75%) were less than standard. As well as the lighting of all dynamics, projects control and storage departments (100%) were less than standard. The illumination intensity of 53.3% of human resources department, 81.81% of engineering analysis stations, 31.25% of systems and methods stations, 66.6% of auto-engineering stations and 70% of laboratory management stations were also lower than the standard.

40.4% of the participants had severe eye fatigue, 28.6% had moderate visual fatigue, 28.6% had low visual fatigue and only 2.4% had no visual fatigue. The average of visual fatigue was 3.50±1.97.

Most of the visual fatigue complaints were because of the drowsiness (94.4%), eye irritation (91.3%), eyelids heaviness (88.9%), eye dryness feeling (87.3 %), eye pain feeling (85.7%), feeling the pressure around the eyes (82.5%) and headache while working (81.7%). Also, 84.9% the participants described the lighting of their works within acceptable limits and 30.2% of them complained the annoying light sources of their workplace.

Discussion

Among all stations of the studied industry, more than $^3/_4$ of the studied points had poor lighting, which was less than 300lux. The majority of the staffs and users of computers (84.9%) described the lighting of their workplace within acceptable limits. In addition, 30.2% of them complained the annoying light source of workplace illumination. On this basis, it can be concluded that despite the staff's satisfaction of lighting sources, some undesirable local lighting was remarkable. Therefore, periodic review and evaluation of the local illumination for all workplaces are recommended. The studies in Shemiranat Health Center, Iran [31], and some libraries and computer sites in Ilam [10] and Zanjan [32], Iran, have shown no optimal lighting.

The majority of computer users had experienced the eye fatigue, so that more than one third of patients had severe eye fatigue and also more than a quarter experienced the average. This is despite the fact that only a very small number of users had no eye fatigue. Research conducted among computer users showed a high frequency of complaints and eye irritation [15, 33], which is matched with the results of our study, too. The most important complaints of users are related to the eye fatigue, whereas in Maa'naviat *et al.* study, eye fatigue has a weak correlation with the total duration of computer use during the day, work experience and light source [34]. Zakerian

et al. have studied the prevalence of ocular diseases in a significant percentage of computer users on average and eye fatigue had a relation with age, working hours and conditions, such as lighting and ergonomic conditions of working with computers in their study [35]. According to the results of similar studies, although people may show a variety of symptoms of visual fatigue, but tearing, sore or heavy eyelids, compliance problems, eye or eyelid ciliary muscle spasms and headaches and eye fatigue were the most common symptoms that may be due to the continuous and long-term look at the computer screen [36]. Based on the results of the study of Rajabi Vardanjani *et al.*, most users of video terminals complain to feel heavy eyelids (77.8%), sore feeling (70.6%), the need to massage the eye (63.3%) and a feeling of pressure in the eye (61.7%), respectively [37, 38]. Ziaee *et al.* have shown that 87.1% of computer users had a little or severe eye fatigue which were related to the age, experience and daily working with computers [20]. Several studies which were conducted on the bank deliveries, typists and computer users in the secretariat and information telephone center operators have demonstrated that the mean score of the eye fatigue at 2 stages (before they start working with computers and 60 minutes after that), had a significant difference. This shows that at least 60min of visual activity and computer use cause changes in the level of the eye fatigue [37]. Eye fatigue caused by working with video terminals and computer reduced the performance of the visual system and they have an inverse relationship with each other [39]. According to the results, it seems that poor lighting in the workplace can cause the eye fatigue and finally a negative impact on people's psychological characteristics [6, 34, 40, 41]. Thus, due to poor lighting in most workstations and high prevalence of the eye fatigue among them, it sounds that a high percentage of the eye fatigues have a relation with poor lighting in workstations. Therefore, the implementation of control measures to adjust working conditions and eye fatigue reduction should be considered. We used questionnaire for eye fatigue assessment. It seems that this method is limited to subjective feedback. Hence it is recommended other experimental methods are included in future works.

Finally, depending on the type of defined tasks in the R&D departments, it is necessary to arrange the light sources in such a way that uniform lighting levels to be achieved. Application of proper frames in order to reducing the lighting loss is recommended. Also, suitable maintenance and replacement of the failed lighting sources is essential. Application of bright color for the walls and roof would be useful for better working in the R&D offices. Therefore, using of radiation shields for display terminals, proper design of the local lighting, providing the general lighting and favorable position in the working surfaces, utilizes a linear light sources with an appropriate level, using of light sources with a high color index (4CRI) in the artificial lighting systems of the workplace, elimination or reduction of resources which have a high lighting levels, providing an even lighting on work surfaces, replacing burned out lamps, periodic cleaning of the light sources, optimum use of the daylight, ergonomic design of the display and planning regular work breaks is essential for providing an optimal lighting status and reducing the eye fatigue levels among the studied personnel.

Conclusion

The workplace lighting and the eye fatigue of computer users in the Research and Development Department of the studied automotive industry are not in an acceptable condition.

Acknowledgements: The authors would like to appreciate all Honorable Managers and the entire workers for their gracious cooperation.

Ethical Permissions: None declared by authors.

Conflicts of Interests: The authors declare that there is no conflict of interests.

Funding/Support: This research project was supported by Qom University of Medical Sciences, Vice Chancellor of Research & Technology.

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