ECRONICON OPEN ACCESS

EC OPHTHALMOLOGY
Research Article

Mitigation of Visual Fatigue through the Use of LED Desk Lights that Provide Uniform Brightness on Visual Work Surfaces

Tomoya Handa[1]*, Yo Iwata[1,2] and Takashi Yuuki[3]

[1]Department of Rehabilitation, Orthoptics and Visual Science Course, School of Allied Health Sciences, Kitasato University, Sagamihara, Japan
[2]Doctor's Program of Medical Science, Kitasato University Graduate School, Kitasato, Sagamihara, Japan
[3]Master's Program of Medical Science, Kitasato University Graduate School, Kitasato, Sagamihara, Japan

***Corresponding Author**: Tomoya Handa, Department of Rehabilitation, Orthoptics and Visual Science Course, School of Allied Health Sciences, Kitasato University, Kitasato, Sagamihara, Japan.

Received: October 11, 2017; **Published:** November 02, 2017

Abstract

We investigated the use of LED desk lights designed to improve the ease of reading and prevent a sense of fatigue. Subjects given a near visual task of reading newspapers exhibited less refractive change after the task when an LED desk light was used to illuminate the entire two-page newspaper spread. Subjective evaluations also found high scores for both reading ease and lack of fatigue. These results suggested that LED desk lights that uniformly illuminate a visual work surface can effectively improve the ease of reading written characters and mitigate the sense of fatigue encountered when performing visual work.

Keywords: *LED (Light Emitting Diode) Lighting; Desk Light; Refraction; Subjective Comfort; Eye Fatigue*

Introduction

With the successful development of low-energy, long-life lighting equipment, light emitting diode (LED) lighting has recently become one of the main types of lighting. However, the legal development of standards and criteria that determine the performance of LED lighting has not kept pace with the rapid spread of this lighting. Given this situation, this study measured and evaluated the effects of LED lighting when performing the type of deskwork that often leads to eye fatigue. Various methods and physiological indicators have been used to assess eye fatigue, including the accommodation response, critical fusion flicker frequency (CFF) value, pupil diameter constriction, and changes in fusional amplitude [1-4]. Our study used refraction measurements as the physiological indicator, as measurements of refraction can be done simply, stably, and with high reproducibility. This investigation included both objective measurements of refractive change before and after a near visual task under different lighting environments, along with subjective evaluations of the improvement in the ease of reading and the lessening of the fatigue encountered after performing visual tasks under LED desk lights.

Methods

Subjects

A total of 30 healthy young adults (12 men and 18 women; mean age ± standard deviation (SD), 20.8 ± 0.91 years old) with no ophthalmological diseases, except for mild refractive errors, were enrolled in the study. The inclusion criteria for this study were as follows: manifest spherical equivalent of -0.50 D or less, when the logMAR CDVA was 0.00 or better, and no strabismus. The study was approved by the Institutional Review Board at Kitasato University School of Allied Health Science. The methods were carried out in accordance with the approved guidelines. Informed consent was obtained from all subjects after explanation of the nature and possible consequences of the study. All tests were conducted with due consideration given to the physical safety of the subjects and under the supervision of healthcare professionals. The tests were discontinued if anyone complained of asthenopia or of not feeling well, no matter how minor the complaint.

Experimental Designs

The near visual task was performed using three different lighting conditions. This experimental setup included an LED desk light (LD520, Panasonic corporation, Japan) that illuminated an entire two-page newspaper spread, an LED desk light (LE-H612, TWINBIRD corporation, Japan) that only partially illuminated the entire newspaper spread, and the absence of any desk light with only general lighting available. Figure 1 shows the experimental setting and the illuminance on the work surface for each the lighting conditions used in the study. The work surface illuminance when using only general lighting (without an LED desk light) was set to be approximately 200 lx in the center of the work surface. The illuminance and color temperature were measured with an illuminance meter (CL-200, Konica Minolta Optics, Inc.). The color temperature of the LED desk light that did not completely illuminate the newspaper spread was 5480k (duv-0.002), while the LED desk light that did illuminate the newspaper spread was 7300k (duv-0.0052). Figure 2 shows the wavelength of the LED desk lights. The wavelength was measured with spectroradiometer (CL-500A, Konica Minolta Optics, Inc.).

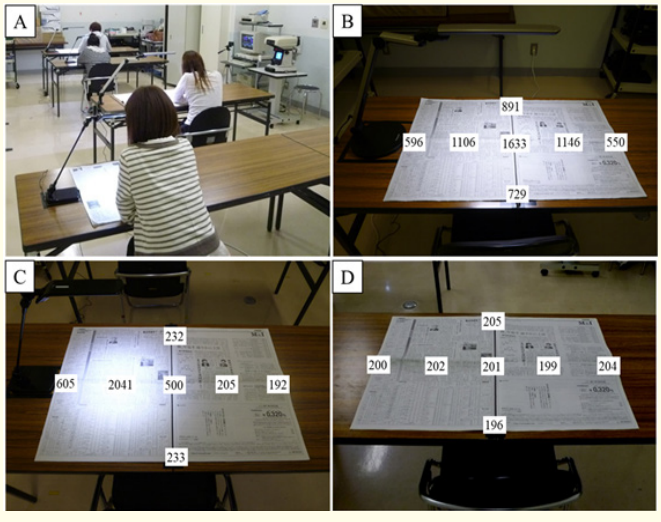

Figure 1: *Experimental setting and illuminance distribution on the work surface for each of the lighting conditions.*

A: Testing environment; B: Work surface illuminance distribution for the LED desk light that completely illuminated the newspaper spread; C: Work surface illuminance distribution for the LED desk light that did not completely illuminate the newspaper spread; D: Work surface illuminance distribution in the absence of a desk light (general lighting only).

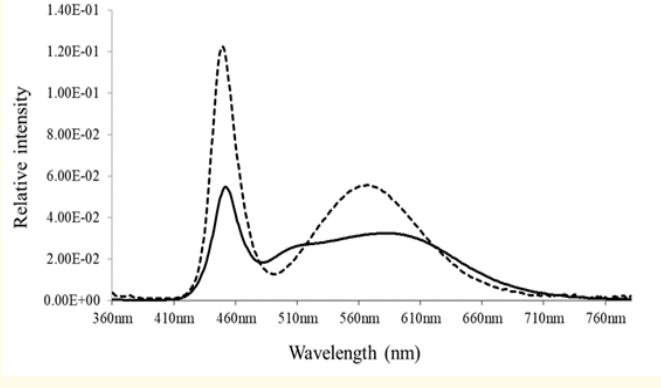

Figure 2: *Spectral of LED desk lights.*

Solid line: Spectral for the LED desk light that completely illuminated the newspaper spread; Dash line: Spectral for the LED desk light that did not completely illuminate the newspaper spread

All subjects sat at a desk and gazed at the surface of a newspaper that was fixed on the desk. The subjects' near visual task was to read articles in the newspaper and then check each of the places they had read with a marker. The time allowed for the near visual task was 90 minutes, with all subjects having an interval of at least one day between the tests with the different lighting environments. Refraction was measured using an auto ref/keratometer (ARK-730A, Nidek, Co, Ltd) before and after the visual task. The mean value that was calculated from three measurements was used as the refraction value. The astigmatic difference was converted to the spherical equivalent. During the refraction measurements, subjects who normally wore glasses to correct refraction removed their glasses so that measurements of their naked eye could be obtained. The subjective evaluation of the reading ease and sense of fatigue under each of the lighting conditions was carried out using a 5-point scale and performed after completion of the 90-minute near visual task. The scores for reading ease were easy to read: 5 points, fairly easy to read: 4 points, neither easy nor difficult: 3 points, fairly difficult to read: 2 points, and difficult to read: 1 point. Sense of fatigue was rated as not fatigued: 5 points, not very fatigued: 4 points, neither fatigued nor not fatigued: 3 points, somewhat fatigued: 2 points, and fatigued: 1 point. Subjects were constantly monitored during the near vision task. The number of newspapers read during the visual task was recorded for each of the lighting conditions. Bonferroni test was used for statistical analysis, with significant differences defined as a significance level < 5%.

Results

None of the subjects complained of asthenopia or feeling unwell at any time throughout the experiment until its conclusion. No significant differences were noted between the refraction values before (-1.07 ± 1.88 D) and after (-1.09 ± 1.88 D) the visual task with the LED desk light that illuminated the two-page newspaper spread ($p > 0.01$), or before (-1.05 ± 1.79 D) and after (-1.20 ± 1.85 D) the visual task with the LED desk light that did not completely illuminate the two-page spread ($p < 0.01$). When the visual task was performed in the absence of any LED desk light, the refraction values before (-1.09 ± 1.78 D) and after (-1.26 ± 1.82 D) were also not significantly different ($p > 0.01$).

Figure 3 shows the refractive changes observed before and after the visual tasks (refraction value before task – refraction value after task) for each of the lighting conditions. No refractive change was seen when the LED desk light illuminated the newspaper spread, with a value of -0.02 ± 0.21 D calculated. However, the refractive change for the LED desk light that did not completely illuminate the newspaper spread was -0.14 ± 0.25 D, which indicates a significant trend for myopia as compared to the LED desk light that illuminated the newspaper spread ($p < 0.05$). Moreover, the refractive change in the absence of any desk light was -0.18 ± 0.28 D, which also indicates a significant trend for refractive change (myopia) as compared to the LED desk light that did illuminate the newspaper spread ($p < 0.01$).

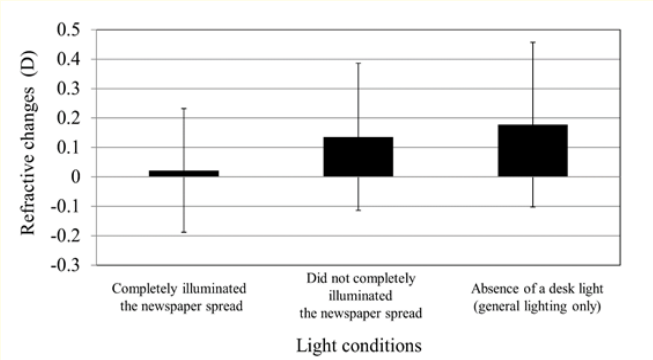

Figure 3: *Refractive change before and after the visual task.*

The value for the refractive change was obtained by subtracting the refraction value before the visual task from the refraction value after the visual task.

Figure 4 shows the subjective evaluation results (total evaluation score calculated from a 5-point scale) for reading ease after the visual task. A high subjective evaluation score of 4.54 ± 0.85 points was observed for the LED desk light that illuminated the newspaper spread. For the LED light that did not completely illuminate the newspaper spread, the subjective evaluation score was 3.09 ± 1.16 points, while without any desk light it was 1.93 ± 0.67 points. A statistically significant difference was found for the subjective evaluation for reading ease when values for the LED desk light that illuminated the newspaper spread were compared to those for the LED desk light that did not completely illuminate the newspaper spread and those without any desk light ($p < 0.01$).

In addition, the subjective evaluation of reading ease showed there was a significant difference between the values for the LED desk light that did not completely illuminate the newspaper spread and those without any desk light ($p < 0.01$).

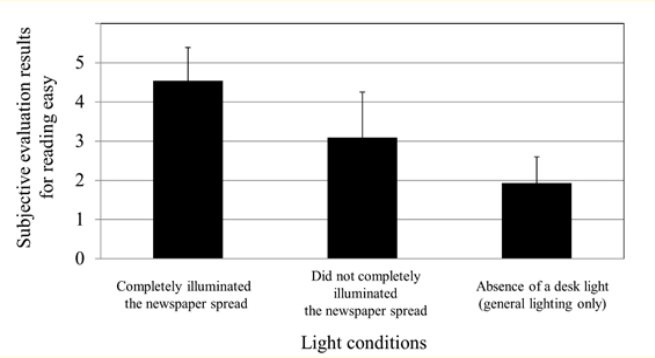

Figure 4: *Results of subjective evaluation after the visual task for reading ease.*

Figure 5 shows the subjective evaluation results (total evaluation score calculated from a 5-point scale) for the sense of fatigue after the visual task. When the LED desk light illuminated the newspaper spread, the subjective evaluation score was 3.29 ± 1.18 points, while it was 2.06 ± 0.92 points when the LED desk light did not completely illuminate the newspaper spread and was 1.32 ± 0.47 points when there was no desk light present. The subjective evaluation for the sense of fatigue with the LED desk light that illuminated the newspaper spread showed a statistically significant difference compared to both the LED light that did not completely illuminate the newspaper spread and without any desk light ($p < 0.01$). In addition, there was also a significant difference between the subjective evaluation values for the sense of fatigue with the LED desk light that did not completely illuminate the newspaper spread and those without a desk light ($p < 0.01$).

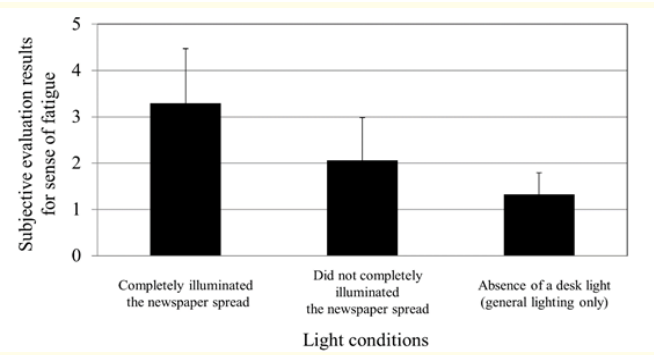

Figure 5: *Results of subjective evaluation after the visual task for sense of fatigue.*

The number of newspaper pages read during the task was 6.97 ± 2.53 with the LED desk light that illuminated the newspaper spread, 6.70 ± 2.47 with the LED desk light that did not completely illuminate the newspaper spread, and 6.12 ± 2.01 in the absence of any desk light. The type of lighting environment present was responsible for a slight, although not statistically significant, difference in the number of newspaper pages read during the task. The subjects' condition was visually monitored during the near task, and a difference in the posture shifting was observed in accordance with the lighting environment. A stable posture and uniform distance was maintained during the task with the LED desk light that illuminated the newspaper spread. In contrast, considerable movement of the task posture along with a tendency to decrease the distance between the eyes and the work surface was observed for both the LED desk light that did not completely illuminate the newspaper spread and when there was an absence of any desk light.

Discussion

It is generally thought that after a certain period of time, a refractive change (transient myopia) occurs in relation to the accommodation of the eye (increase in lens refractive power) after a near visual task. Almost no refractive change was found either before and after the visual tasks in this study, even after a near visual task of 90 minutes with an LED desk light that completely illuminated the newspaper spread. However, when the results for the near visual task that was performed under the LED desk light that illuminated the newspaper spread was compared to both the near visual task performed under the LED desk light that did not completely illuminate the newspaper spread and the absence of a desk light, there was a significant refractive change (myopia) seen. The ciliary muscles contract for focus (accommodation) when performing a near visual task, thereby producing a refractive change in the lens. Thus, the reason for the above difference is thought to be due to the large area of lighting that was present when the LED desk light illuminated the newspaper spread. Since clear vision was achieved when the full newspaper spread was illuminated with a uniform brightness of more than 500 lx, this made it possible to maintain a constant work posture without having to move the eyes closer to the newspaper surface. These results suggest that there was neither excessive accommodation of the eye nor any refractive change before or after the visual task. In contrast, the LED desk light that did not completely illuminate the newspaper spread provided a narrower illumination area, and when no desk light was available (general illumination only) the entire newspaper surface was in the dark. Thus, in order to be able to clearly see the written characters on the newspaper page during these situations, it was necessary to move the eyes closer to the newspaper surface. Therefore, these results suggest that there was induction of excessive eye accommodation and a tendency for myopia to be produced after the task.

Subjective evaluations indicated that both the reading ease and sense of fatigue were significantly better with a LED desk light that illuminated the newspaper spread as compared to the lighting conditions with a LED desk light that did not completely illuminate the newspaper spread and when no desk light was available. Previous studies have also reported finding that visual system fatigue is related to the ease of seeing written characters [5]. Our present findings suggest that LED desk lights that uniformly illuminate the entire work surface make it easier to read written characters, thereby effectively reducing the refractive change and sense of fatigue.

Conclusion

LED desk lights that uniformly illuminate a visual work surface can effectively improve the ease of reading written characters and mitigate the sense of fatigue encountered when performing visual work.

Bibliography

1. Peli E. "The visual effects of head-mounted display (HMD) are not distinguishable from those of desk-top computer display". *Vision Research* 38.13 (1998): 2053-2066.

2. Oohira A and Ochiai M. "Influence on visual function by a stereoscopic TV programme with binocular liquid crystal shutter and Hi-vision TV display". *Ergonomics* 39.11 (1996): 1310-1314.

3. Emoto M, *et al*. "Changes in fusional vergence limit and its hysteresis after viewing stereoscopic TV". *Display* 25.2-3 (2004): 67-76.

4. Kawamorita T., *et al*. "Relaxation effect on eye fatigue with the use of filter for liquid crystal displays". *Japanese Journal of Visual Science* 24 (2003): 85-89.

5. Yamamoto S. "Visual, musculoskeletal and neuropsychological health complaints of workers using video display terminal and an occupational health guideline". *Japanese Journal of Ophthalmology* 31.1 (1987): 171-183.

Volume 8 Issue 3 November 2017