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Effect of Illumination over Positive Fusional Vergence when Using VDU as Target

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Abstract

Background: To find out the changes in the positive fusional vergence at near, under different room illuminations while using VDU (Visual Display Unit) as a target.

Method: A cross sectional study was performed by using convenience sampling method. The study subjects comprised of 33 Malaysians aged between 15 to 35 years regardless of race and gender. This research was done within a period of six months (April 2015 to September 2015) at Twintech vision clinic. The data were analyzed by using a repeated measure Friedman Test to investigate the changes in positive fusional vergence at near under different room illuminations.

Result: 33 subject's data were analyzed, out of which 17 male and 16 female. Positive fusional vergence at near changed significantly in three different levels of room illumination (p=0.012, p=0.003 and p=0.006 for Blur, Break and Recovery respectively). However, positive fusional vergence between gender was not significant (p>0.05).

Conclusion: There is a statistically significant difference in positive fusional vergence for near under different level of illuminations. Moreover, under low illumination the positive fusional vergence seems to be higher. There is no significant difference observed between genders for positive fusional vergence at near.

Keywords: Positive fusional vergence; Room Illuminations; VDU user; Base out prism

Introduction

With the advent of information and advanced technology, the use of Video Display Terminals (VDTs) has become widespread. Flat panel displays or personal computers (PC) have become standard components of the workplace and home. The use of VDTs has been associated with various eye symptoms such as eye strain, headache, focusing problems, and dry eye [1]. The concern about the potentially harmful effects of VDTs on the human eye has grown with the introduction of computers to the general population in the early 1980s. Due to inadequate awareness concerning VDT ergonomics, symptoms were linked to ocular fatigue [1]. The Japanese Ergonomic Society was first to produce VDT ergonomics standard guidelines to maintain good occupational health [2]. This highlights the importance of worker position, viewing angle, display setting, and position of the chair and the desk. The environmental lighting system is also a major contributing factor for VDT related eye fatigue [3]. According to OSHA, the average illumination recommended for VDU workstations should be between 300 lux to 700 lux [4].

Study show that accommodation and convergence play a vital role during sustained near tasks and are influenced by different illumination levels [5]. During reading the eye focuses an image of words onto the retina. The iris, as well as the muscles that control the shape of lens contract to keep the focused image over the retina. Reading in low levels of illumination cause the muscles to get mixed signals [6]. Iris will relax to collect the light, but at the same time, the ciliary muscle contracts to maintain the focused image. When an object is poorly lit, focusing becomes even more difficult because the contrast between the words and the page is not adequate.

The eyes have to strain more to distinguish the words on the page. When this occurs for an extended period of time it leads to eye strain including asthenopia, headaches, back and neck ache, drooping of eyelids, and blurred vision. A decreased blink rate may lead to uncomfortable dryness in the eyes [6].

Research investigating accommodation and convergence levels by showing a 3D object in two different illuminations demonstrated that accommodation focuses beyond the convergence at brighter illumination whereas, in darker illumination, accommodation and convergence were similar in location [7]. Several studies, including those on ergonomics, show that illumination is not the only factor that influences the level of convergence among VDU users. The viewing distance and angle of regard are also key components [7-10]. The efficiency of visual stabilization also depends on many factors such as target, size, luminance location, visual acuity, and posture [11-15]. However, Atchinson et al. assessed the Hess-Gullstrand theory where with increasing age there is an increasing excess amount of ciliary muscle contraction beyond the ability of the lens and capsule to respond to it [16]. He has assessed the effect of direction of eye gaze and head posture on the amplitude of accommodation for two age groups. In these study far points, near points, and amplitude of accommodation was determined for young group (18 to 25 years) and an older group (35 to 45 years). Small but significant shifts of near points toward the eye were observed when the head position or eye gaze was shifted from above to below the horizontal, for the younger observers only (the maximum mean difference between conditions was 1.1 D, compared with a mean accommodation level of 9.8 D for this young group. So, Atchinson et al. concluded that extra attention not required for head and eye position during clinical measurements of the amplitude of accommodation. Because the shift of the near point was noted only for the younger group, their study does not support the Hess-Gullstrand theory [17].

Wolska et al. showed that convergence plays a crucial role in low illumination compared to accommodation. In the study, near point of accommodation and convergence was measured using an RAF (Royal Air Force) ruler under four different room illuminations using a VDU as a target [18]. Okada stated that during high illumination the pupils are miotic and the amount of accommodation and convergence are low. In low illumination when the pupils are mydriatic, the convergence and accommodation levels are focused beyond the plane of regard compared to the brighter environment [5].

Although previous studies have shown a correlation between convergence and illumination but still no such study has reported the effect of illumination over Positive fusional vergence at near. The main aim of this study is to investigate changes in the positive fusional vergence at near under different room illuminations while viewing a VDU.

Material and Methods

A cross-sectional study was conducted with 33 Malaysian subjects, aged 15 to 35 years for a period of six months (April 2015 to September 2015) at the Twintech Vision Care Centre, Malaysia. Out of 33 subjects; 17 subjects were male (51.5%) and 16 subjects were females (48.5%). Written informed consent was obtained from all the participants and the study was performed in accordance with the tenets of the declaration of Helsinki. Inclusion criteria were subjects with a best corrected visual acuity of 6/6 and N6, age group of 15-35 years whereas subjects having any ocular pathology, presbyopia, eye movement disorder, binocular vision anomaly, systemic illness, and current contact lens wearers were excluded from the study. A detailed history was obtained followed by measurement of visual acuity with log MAR chart, objective and subjective refraction, pupillary evaluation, near point of accommodation and near point of convergence with RAF ruler, negative and positive relative accommodation, negative and positive fusional vergence for both distance and near with prism bar, accommodative and vergence facility with accommodative and vergence flippers, monocular estimated method, cover test with accommodative target, version and duction eye movements, slit lamp examination, and fundus examination. After successful completion of the initial assessments, those who passed the inclusion criteria were included in the study. The amount of positive fusional vergence was measured by using a prism bar under three different room illuminations (7 Lux, 19 Lux and 33 Lux based on the availability of illumination in the clinical set up) using a VDU as a target. All measurements were performed in a high to low illumination level sequence. A table was equipped with a chin rest along with an adjacent protector to ensure a constant viewing distance (33 cm) and viewing angle (30 degrees). A vertical target of N6 size was shown on a VDU with a constant brightness (80%) throughout the test. The subject was asked to place their chin on the rest; the 30-degree viewing angle was adjusted from the outer canthus with the help of protractor. While focusing on the vertical target the examiner held a base out prism in front of the right eye and the amount of positive fusional vergence were measured binocularly. When the examiner initially placed the prism in front of subject's eye, the subject needed to make sure the target was clear enough to read without effort. The amount of base out prism was increased slowly, until the subject reported of seeing the target blur and then double, indicating the break. The amount of base out prism was decreased gradually until the subject reclaimed fusion, indicating recovery. The blur, break, and recovery were recorded in prism diopter during the three illumination levels. For each illumination level, an average of three readings was taken to determine the final amount of base out prism. The statistical analysis was carried out by using the statistical package for Social Science (SPSS Inc., Chicago, IL, USA) version 19.0, G-Power and Microsoft Office Excel 2007. Normality of data was evaluated with the help of Shapiro-Wilk test. The results were expressed as mean ± SD if the variable was continuous and as number (percentage) if categorical, unless otherwise mentioned. Friedman Test was performed based on the finding of normality test, to compare the amount of positive fusional vergence under three different room illuminations when using VDU as near target. The difference in positive fusional vergence between genders was performed by using Mann-Whitney U Test. The p values of less than 0.05 were considered statistically significant. Data collection procedure was summarized in Figure 1.

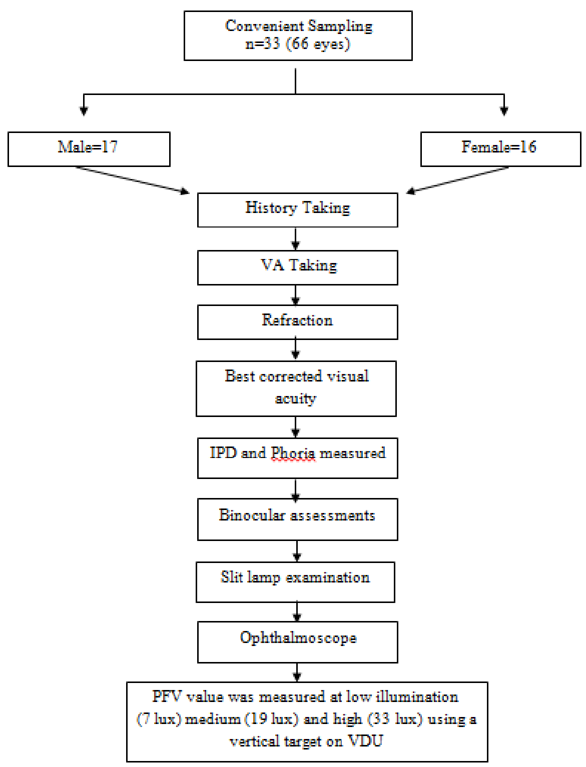

Figure 1: Shows the data collection procedures.

Results

Data was not normally distributed when Shapiro-Wilk test was done to check the normality of the data as shown in Table 1. No clinically significant relationship was observed between genders for different

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levels of illumination (Table 2). A clinically significant difference was observed for positive fusional vergence for three different levels of room illuminations. Friedman analysis showed a statistically significant influence of illumination on positive fusional vergence at near for blur (p=0.012), break (p=0.003) and recovery point (p=0.006). The average value of positive fusional vergence at low illumination (blur=10.06, break=13.69 and recovery=11.31) was higher in comparison to the positive fusional vergence value at high illumination (blur=10.13, break=13.01 and recovery=10.48) and medium illumination (blur=10.28, break=13.18 and recovery=11.01) as shown in Tables 3 and 4.

PFV_Near	Gender	N	Mean Rank	Sum Rank	P value
BLUR_H	M	17	18	306	0.538
	F	16	15.94	255	
BLUR_M	M	17	18.21	309.5	
	F	16	15.72	251.5	0.458
BLUR_L	M	17	19.74	335.5	
	F	16	14.09	225.5	0.092
BREAK_H	M	17	17.44	296.5	
	F	16	16.53	264.5	0.785
BREAK_M	M	17	18.41	313	0.384
	F	16	15.5	248	
BREAK_L	M	17	17.76	302	
	F	16	16.19	259	0.638
RECOVERY_H	M	17	16.74	284.5	
	F	16	17.28	276.5	0.87
RECOVERY_M	M	17	16.79	285.5	0.899
	F	16	17.22	275.5	
RECOVERY_L	M	17	17.06	290	0.971
	F	16	16.94	271	
*Mann-Whitney U test *p<0.05					

Table 1: Comparison of positive fusional vergence between genders in three different illuminations.

PFV_Near	Mean Rank	Mean ± SD	P value
BLUR_H	1.76	10.1364 ± 3.67056	
BLUR_M	1.92	10.2879 ± 3.69973	0.012
BLUR_L	2.32	10.0697 ± 4.47084	
*Friedman Test *P<0.05			

Table 2: Comparison of blur point of positive fusional vergence at near for three different room illuminations.

PFV_Near	Mean Rank	Mean ± SD	P value
BREAK_H	1.76	13.0152 ± 2.52018	
BREAK_M	1.82	13.1818 ± 2.17880	0.003
BREAK_L	2.42	13.6970 ± 2.63670	

*Friedman Test	*P<0.05

Table 3: Comparison of break point of positive fusional vergence at near for three different room illuminations.

PFV_Near	Mean Rank	Mean ± SD	P value
RECOVERY_H	1.64	10.4848 ± 2.49213	
RECOVERY_M	2.08	11.0152 ± 2.33681	0.006
RECOVERY_L	2.29	11.3182 ± 2.31104	
*Friedman Test *P<0.05			

Table 4: Comparison of recovery point of positive fusional vergence at near for three different room illuminations.

Discussion

In this study, we measured the subjects' positive fusional vergence while viewing a VDU at near target under three lighting levels. The blur, break and recovery points were recorded and analyzed. There were no statistically significant differences in positive fusional vergence for blur, break recovery at near between genders for different illumination levels. The findings of Agnieszka et al. showing no correlation between gender and positive fusional vergence with a change of illumination, measured among VDT professionals, support our study's findings [18]. At present we didn't find any study that contradicts these study findings.

The main purpose of this study was to investigate the relationship between positive fusional vergence and room illumination. The findings affirmed that value of positive fusional vergence increased with decreasing room illumination. Our findings were supported by Okada et al. where they measured accommodative and convergence demand while viewing a 3D object in two lighting conditions. They observed that in low illumination, the accommodative and convergence demands were higher compared to a brighter environment [5]. According to Agnieszka et al., the greater reduction in convergence occurs, especially in a brighter environment [18]. Convergence and illumination have correlated significantly due to the change in pupillary size. In low illumination the pupil size increases and the depth of focus decreases. The eyes tried to accommodate and converge more to make the image clear on the retina whereas in high illumination the depth of focus increases and the depth of field decreases. Therefore, less accommodation and convergence required to create a clear retinal image.6 Besides that, when the object poorly lit, focusing becomes even more difficult because of the contrast between the words and the page, which decreases the eye's ability to distinguish visual details [6]. So, poor lighting causes greater exertion of positive fusional vergence which can lead to asthenopic or visual fatigue symptoms after prolonged work.

This study didn't include the ethnicity in a proper proportion (Malay, Chinese, Indian and Bumiputeras) to draw any significant relationship between ethnicity and positive fusional vergence for near which is one of the limitation of this study, as it was observed previously that with increasing near exophoria due to larger IPD (Inter papillary distance), compensating convergence ranges decreases [19]. Parameters like pupil size and contrast were not measured which might have altered the study results. So, it is recommended to include above-mentioned factors for future study.

Conclusion

There is a statistically significant difference in positive fusional vergence for near under different level of illuminations. But it's clinical significance need to be assessed in more details. Under low illumination; the positive fusional vergence value is higher which can leads to various asthenopic symptoms after prolonged work. So, illumination is one of the important factors to consider while doing near task.

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