

Comparison of Amplitude of Accommodation in Different Room Illumination while Using VDU as a Target

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ABSTRACT

AIM: To compare the amplitude of accommodation (AA) in different room illumination while using visual display unit (VDU) as a target.

METHOD: A non randomized, cross sectional study includes 32 Malaysians aged between 15 to 35 years despite of races and gender. Convenience sampling method applied. The data analysis carried out by using one way repeated measure ANOVA, to look into the changes in amplitude of accommodation in different illuminations (23 Lux, 17 Lux and 4 Lux).

RESULT: 32 subjects' data analyzed. Amplitude of accommodation measured via minus-lens method. No significant change noted among three levels of room illumination ($p > 0.05$) with the mean difference of 0.222DS from the first room illumination to third room

illumination. Further, to associate AA among genders, age groups, race and refractive error for different levels of room illumination was not significant ($p > 0.05$). However, amplitude of accommodation between 15-21 years and 22-28 years showed significant ($p = 0.047$) difference for the first room illumination.

CONCLUSION: The illumination has no clinically significant effect on amplitude of accommodation.

Key words: Amplitude of Accommodation; Room illumination; Visual display unit (VDU); Minus lens method

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INTRODUCTION

Since 1972, research into the effects of the VDU on the eye expanded^[1]. Due to technological advances, millions of people such as office worker and college students are using computers for prolonged hours. However, after prolonged uses of these visual display units, the symptoms reported were eyestrain, tired eyes, headache, blurred vision, irritation, burning sensation, redness, double vision, neck pain, backache which might caused by combination of individual visual problems, poor workplace conditions and improper work habits^[2-3]. On top of that, eye related symptoms reported as the most common health problem among VDT users^[4-6].

To measure amplitude of accommodation is one of the necessary part of an eye examination to find out optimal refractive corrections and to reduce the eye related symptoms when doing near work especially while using visual display unit as a target. In addition, accommodation was proven to have association with the symptom of visual fatigue and asthenopia while doing near work. Abnormality associated with accommodation such as accommodative insufficiency, accommodative infacility and lag of accommodation reported among video display terminal (VDU) users in Nepal^[7].

Several other studies have shown that visual tasks using visual display unit (VDU) terminals may induce temporary effects in the

visual accommodation system^[8-9]. However, there are studies which suggest that other causes such as work station lighting and screen quality may induce visual problem of the task^[9].

As mentioned above, use of visual display unit not only limited among computer workers, but also among teenagers and youth who use it for entertainment or doing college works. These different groups of people may perform their near work with visual display unit under variable room illumination. Previous study showed that accommodation fatigue causes decrease of visual performance due the variety of room illuminations^[10]. However, according to Shahnava *et al* there is no significant correlation between accommodation changes and workstation lighting with the visual fatigue among visual display unit users^[11]. So, the aim of this study is to find out any change in amplitude of accommodation occurs or not under different room illuminations, while using the visual display unit as a target.

MATERIAL AND METHODS

Study design and sampling

A cross-sectional study performed with the help of 32 Malaysian subjects, aged 15 to 35 years. The duration of the study period was six months (January 2015 to June 2015) and the study conducted at Twintech Vision Care Center, Malaysia. All the participants need to sign written informed consent before carrying out the study. Permission to conduct the study obtained from the institute and all procedures performed after following the declaration of Helsinki. A convenient sampling technique used.

Inclusion and exclusion

The inclusion criterion of the study was subjects with a best corrected visual acuity of 6/6 and N6. Subjects with any ocular pathology, presbyopia, eye movement disorder, binocular vision anomaly, systemic illness, and contact lens wearers excluded.

Procedure

Detailed history obtained from each subjects followed by measurement of visual acuity, objective and subjective refraction, pupillary evaluation, Near point of accommodation, Near point of convergence, Negative and positive relative accommodation, Negative and Positive fusional vergence for both distance and near, accommodation and vergence facility, Monocular estimation method, cover test, version and duction eye movements, slit lamp examination, and fundus examination. Those who successfully complete early assessments included in the study. "Minus lens method" used to measure amplitude of accommodation under three different room illuminations using VDU as a target. The room attuned with three different levels of room illuminations: 23 Lux (1st), 17 Lux (2nd) and 4 Lux (3rd) based on the availability of illumination in the clinical set up. All measurements done from high to low levels of illumination. Three marks drawn in the illumination adjusting unit and whenever the starting point mark of the rotating knob coincides with those three (fixed) different markings, illumination measured with the help of Lux meter for each marking. A table equipped with a chin rest and an adjacent protector to make a constant viewing distance (33 cm) and viewing angle (30 degrees). A horizontal target of N6 size given on a VDU with a constant brightness (80%) which was same throughout the test. The subject asked to place their chin over the chin rest and the viewing angle of 30 degree adjusted from the outer canthus with the help of a protractor during each measurement to avoid bias. The testing distance fixed and measured with a ruler.

All measurements taken from the plane of trial frame. Patients those who wear spectacles, their refractive correction substituted to the trial frame before measuring the amplitude of accommodation. Subjects positioned in a headrest to ensure consistency of eye and head position. The target used was a visual display unit (Apple I-pad 2, with height of 9.50 inches and width of 7.31 inches) with a screen display of 9.7-inch (diagonal) LED-backlit glossy widescreen Multi-Touch display with IPS technology and screen resolution of 1024-by-768-pixel resolution at 132 Pixels Per Inch (PPI). Subjects tested with their best refractive correction. Measurements made on right eyes with left eyes occluded and the order reversed. Throughout the research, target remains at a fixed position (33cm and 30 degree downward gaze). The minus lenses offered in 0.25Ds step and a constant vertex distance of 12mm preserved throughout the research. The subjects asked to inform the first noticeable, continued blur that cannot cleared by conscious effort. The amplitude of accommodation is combining minus lens power introduced plus the 3.00Ds needed to focus initially on the target. The target distance of 33cm maintained rather than 40 cm to compensate the minification effect induced by minus lens and reduce the possibility of getting underestimated amplitude of accommodation. In addition, a constant viewing distance and angles can achieved easily by using the minus lens rather than the push-up method.

Statistical Analysis

The Statistical analysis done by using statistical software package Statistical Package for Social Science software (SPSS Inc., Chicago, IL, USA) version 22.0 and Microsoft Office Excel 2007. Shapiro-Wilk test was done to check the normality of the data. The results expressed as mean \pm standard deviation if the variable is continuous and as number (percentage) if the categorical, unless otherwise mentioned. To assess the amplitude of accommodation changes among refractive error groups, age groups and three different room illuminations, one way repeated measure ANOVA performed. Post hoc analysis also performed to find out the potential differences within the groups. To evaluate the changes in amplitude of accommodation for gender and race, T-test performed. A p value of less than 0.05 considered significant.

RESULTS

This study had 32 subjects; 19 subjects were male (59.4%) and 13 subjects were females (40.6%) which shown in figure 1. All subjects were within an age group of 15 to 35 years. Subjects grouped into two races: Malay (81.3%) and Non Malay (18.7%) as shown in figure 2. Distribution of refractive error showed more or less equal distribution of myopia (34.4%), hypermetropia (32.8%) and emmetropia (32.8%) as shown in figure 3. Table 1 showed no statistically significant difference ($p > 0.05$) for amplitude of accommodation in different room illumination for gender. Comparison of amplitude of accommodation within three different age groups also showed no statistically significant difference ($p > 0.05$) as shown in Tables 2 and 3. However, amplitude of accommodation between 15-21 years and 22-28 years showed significant ($p = 0.047$) difference for the first room illumination. Comparison of amplitude of accommodation with race and refractive error showed no statistically significant differences for three different room illuminations as shown in Tables 4 and 5 respectively. Table 6 showed no significant relationship within the refractive error groups for different levels of illumination. Amplitude of accommodation and illumination levels has no significant relationship as shown in Tables 7 and 8.

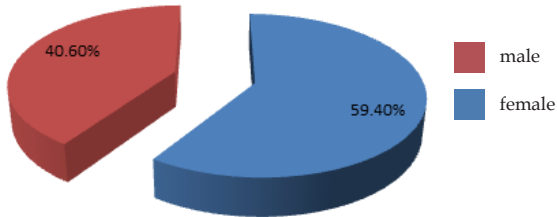


Figure 1 Showed distribution of gender where 59.4% are male and 40.6% are female.

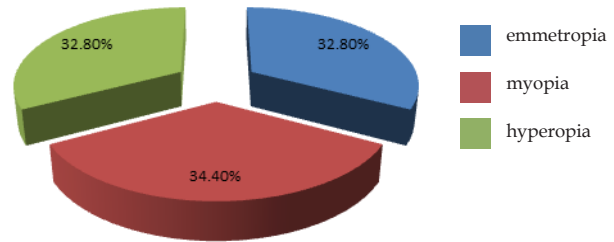


Figure 3 Showed distribution of refractive errors where 32.8% is emmetropia, 34.4% is myopia, and 32.8% is hyperopia.

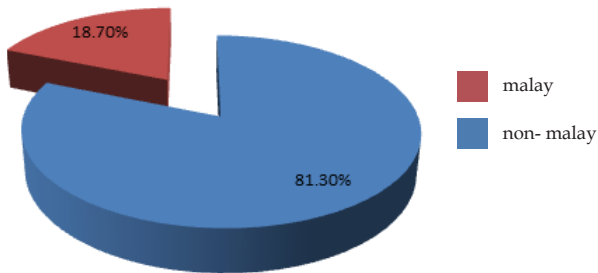


Figure 2 Showed distribution of race where 81.3% is Malay and 18.7% is non-Malay.

Table 1 Comparison of amplitude of accommodation in different room illumination between genders.

Illumination level	Gender	Mean ± SD	p value
1st	Male	9.5089 ± 2.30581	0.529
	Female	9.1204 ± 2.47685	
2nd	Male	9.7437 ± 2.56533	0.459
	Female	9.2612 ± 2.52262	
3rd	Male	9.8321 ± 2.56622	0.302
	Female	9.1935 ± 2.29448	

p < 0.05 is considered significant.

Table 2 Comparison of amplitude of accommodations within three different age groups in three different room illuminations.

Illumination	Age	Mean ± SD	p value
1st	15-21	9.7046 ± 2.56485	0.049
	22-28	9.0513 ± 0.58068	
	29-35	7.5300 ± 1.04369	
2nd	15-21	9.8904 ± 2.78031	0.067
	22-28	9.3838 ± 0.54809	
	29-35	7.6550 ± 0.94491	
3rd	15-21	9.8354 ± 2.71879	0.123
	22-28	9.6550 ± 0.42258	
	29-35	7.9138 ± 1.03695	

p < 0.05 is considered significant.

Table 4 Comparison of amplitude of accommodation with race in three different room illuminations.

Illumination level	Race of participant	Mean ± SD	p value
1st	Malay	9.3210 ± 2.49092	0.799
	Non-malay	9.4817 ± 1.80223	
2nd	Malay	9.5165 ± 2.69864	0.796
	Non-malay	9.6825 ± 1.77085	
3rd	Malay	9.4671 ± 2.59566	0.379
	Non-malay	10.0300 ± 1.78058	

p < 0.05 is considered significant.

Table 3 Post hoc test showed no significant difference within age groups for levels of illumination.

Dependent Variable	(I) Age of participant	(J) Age of participant	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
AA in 1st illumination	15-21	22-28	0.653	0.874	1	-1.497	2.804
		29-35	2.17458*	0.874	0.047	0.024	4.325
	22-28	15-21	-0.653	0.874	1	-2.804	1.497
		29-35	1.521	1.144	0.565	-1.294	4.337
	29-35	15-21	-2.17458*	0.874	0.047	-4.325	-0.024
		22-28	-1.521	1.144	0.565	-4.337	1.294
AA in 2nd illumination	15-21	22-28	0.507	0.943	1	-1.814	2.827
		29-35	2.235	0.943	0.063	-0.085	4.556
	22-28	15-21	-0.507	0.943	1	-2.827	1.814
		29-35	1.729	1.234	0.499	-1.310	4.767
	29-35	15-21	-2.235	0.943	0.063	-4.556	0.085
		22-28	-1.729	1.234	0.499	-4.767	1.310
AA in 3rd illumination	15-21	22-28	0.180	0.923	1	-2.091	2.452
		29-35	1.922	0.923	0.125	-0.350	4.193
	22-28	15-21	-0.180	0.923	1	-2.452	2.091
		29-35	1.741	1.208	0.464	-1.233	4.716
	29-35	15-21	-1.922	0.923	0.125	-4.193	0.350
		22-28	-1.741	1.208	0.464	-4.716	1.233

*. The mean difference is significant at the 0.05 level.

DISCUSSION

The objective of this study is to find out the relation between amplitude of accommodation and room illumination. This study also tried to prove another interesting relationship between gender, age, race and refractive error with amplitude of accommodation at three different room illuminations. No statistically significant difference in amplitude of accommodation between gender for three different room illuminations ($p > 0.05$) noted. Our study finding supported by Yavas *et al*'s study ($p = 0.54$) although both the study

uses different techniques to measure amplitude of accommodation (i.e. minus lens technique and infra-red photorefractor technique respectively)^[12]. However, this study noted the difference of amplitude of accommodation for three different room illuminations at 30° downward gaze in compare to Yavas *et al*'s study where they have viewed the difference of amplitude of accommodation at primary gaze^[12]. There is no previous study which can contradict or support our study for amplitude of accommodation at three different illumination level and gender.

When amplitude of accommodation for three age groups (15-21, 22-28, 29-35 years) compared, no statistically significant difference in amplitude of accommodation found among three groups for second room illumination ($p = 0.067$) and third room illumination ($p = 0.123$), but a significant difference noted for the first room illumination ($p = 0.049$). This study results contradict Atchison *et al*'s result where they found a significant relation between age group

Table 5 Comparison of amplitude of accommodation with refractive errors in three different room illuminations.

Illumination level	Refractive error	Mean ± SD	p value
1st	Emmetrope	10.2200 ± 1.50870	0.121
		8.9336 ± 2.93572	
		8.9195 ± 2.26174	
2nd	Emmetrope	10.4071 ± 1.75534	0.159
		9.2500 ± 2.90452	
		9.0000 ± 2.67987	
3rd	Emmetrope	10.6414 ± 1.83415	0.05
		9.0941 ± 2.57929	
		9.0052 ± 2.63437	

$p < 0.05$ is considered significant.

Table 7 Comparison of Amplitude of Accommodation in three different room illuminations.

Illumination level	Amplitude of Accommodation (D) Mean ± SD	p value
1st	9.3511 ± 2.36516	0.118
2nd	9.5477 ± 2.53915	
3rd	9.5727 ± 2.46105	

$p < 0.05$ is considered significant.

Table 6 Post hoc test showed no significant difference within refractive errors for levels of illuminations

Dependent Variable	(I) Refractive error of participant	(J) Refractive error of participant	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
AA in 1st illumination	emmetrope	myope	1.286	0.708	0.223	-0.457	3.030
		hyperope	1.300	0.717	0.223	-0.463	3.064
	myope	emmetrope	-1.286	0.708	0.223	-3.030	0.457
		hyperope	0.014	0.708	1	-1.730	1.758
	hyperope	emmetrope	-1.300	0.717	0.223	-3.064	0.463
		myope	-0.014	0.708	1	-1.758	1.730
AA in 2nd illumination	emmetrope	myope	1.157	0.764	0.405	-0.723	3.038
		hyperope	1.407	0.773	0.221	-0.495	3.309
	myope	emmetrope	-1.157	0.764	0.405	-3.038	0.723
		hyperope	0.25	0.764	1	-1.631	2.131
	hyperope	emmetrope	-1.407	0.773	0.221	-3.309	0.495
		myope	-0.25	0.764	1	-2.131	1.631
AA in 3rd illumination	emmetrope	hyperope	1.636	0.735	0.089	-0.173	3.445
		myope	-1.547	0.726	0.112	-3.336	0.241
	myope	hyperope	0.089	0.726	1	-1.699	1.877
		emmetrope	-1.547	0.726	0.112	0.241	-3.336
	hyperope	myope	-0.089	0.726	1	-1.877	1.699
		emmetrope	1.636	0.735	0.089	3.445	-0.173

*. The mean difference is significant at the 0.05 level.

Table 8 Post hoc test showed no significant difference within Amplitude of Accommodation for levels of illumination.

Pairwise Comparisons						
(I) AA	(J) AA	Mean Difference (I-J)	Std. Error	Sig.a	95% Confidence Interval for Differencea	
					Lower Bound	Upper Bound
1st	2nd	-0.197	0.099	0.158	-0.441	0.048
	3rd	-0.222	0.14	0.352	-0.565	0.122
2nd	1st	0.197	0.099	0.158	-0.048	0.441
	3rd	-0.025	0.096	1	-0.261	0.211
3rd	1st	0.222	0.14	0.352	-0.122	0.565
	2nd	0.025	0.096	1	-0.211	0.261

$p < 0.05$ is considered significant.

and eye gaze direction for both nearpoint and amplitude ($p < 0.05$) but not for far point ($p = 0.31$)^[13]. The age group of 15-35 recruited for our study because normal amplitude of accommodation need to be measured. Unequal distribution of subjects is the reason why we did not find any significant difference between the amplitude of accommodation for second and third room illuminations and age group compared to Atchison *et al*'s study^[13]. In this study most of our subjects fall under the age group of 15-21 years. Further, Atchison *et al* study measures amplitude of accommodation in different eye gaze done by using push-up method whereas minus lens technique used for this study for three illumination, which could be the possible reasons for the discrepancy between our findings and Atchison *et al*'s study findings.¹³ Besides, we didn't find any study that either agree or contradict our results about the significant interaction between the room illumination and the age groups.

This study didn't show any significant difference in the amplitude of accommodation among race for three different room illumination (first room illumination $p = 0.799$, second room illumination $p = 0.796$ and third room illumination $p = 0.379$). This study finding for the amplitude of accommodation among race contradicts Edwards *et al*'s study, where the effect of race has reported to influence the amplitude of accommodation. Caucasian subjects having higher amplitude of accommodation than Chinese subjects^[14]. The possible difference between our study and Edwards *et al*'s st is because of the method and ethnicity difference. This study used minus lens technique whereas Edward *et al* used push up technique to measure amplitude of accommodation. Moreover, in this study majority of the subjects were Malay in compare to Edward *et al*'s study where chinese predominance was more. This study didn't show any statistically significant difference in the amplitude of accommodation among different refractive error groups for three different room illuminations (first room illumination $p = 0.121$, second room illumination $p = 0.159$ and third room illumination $p = 0.050$)^[14]. However, there is no previous study is there to support or contradict our results in a sense to prove a significant interaction between refractive error and amplitude of accommodation for three different room illumination.

Although the main purpose of this study is to find out the relationship between amplitude of accommodation and different room illumination. There is no statistically significant relationship exists between amplitude of accommodation and different room illumination ($p = 0.118$). Furthermore, we have established that amplitude of accommodation increases from the first room illumination to the third room illumination with the mean difference of 0.222DS. This study finding contradicts Gur *et al*'s finding where amplitude of accommodation decreased of 0.69DS among the VDU workers, before and after work examination with significance value of ($p < 0.0001$)^[15]. Due to the method difference a large discrepancy exists between the two study result. This study used minus lens technique whereas Gur *et al*'s study used push-up method with non-illuminated target to measure the amplitude of accommodation. Besides that, measurement of AA done under three different room illuminations for this study but Gur *et al* study was performed under fixed room illumination^[15]. In another study by M Shivaram *et al* also showed no significant difference in NPA ($p = 0.43$) with different spectral distribution of light which supports our study findings^[16].

CONCLUSION

Changing the level of room illumination has no significant effect on

amplitude of accommodation, although amplitude of accommodation (AA) increased with a decrease of room illumination. In addition to that age group, gender, race and refractive error also showed no significant effect on amplitude of accommodation for three different room illuminations except age group for the first room illumination.

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