THE EFFECT OF 6-PRISM BASE-OUT AT 6-METRE FIXATION ON VERGENCE AND ACCOMMODATION SYSTEMS

NUR MUNIRAH ABU BAKAR

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Abstract

Introduction: Prisms is used for binocularity diagnosis and vision therapy in optometry particularly in treating symptomatic vision anomalies such as divergence excess, convergence insufficiency, nystagmus and concomitant as well as incomitant strabismus. This utilization of base-out prism in the alteration of vergence and accommodation system is not well explored especially on normal binocular vision. This study aimed to assess the effect of prism base-out inducement on vergence and accommodation among normal binocular vision system. **Aim:** To compare the value of positive fusional vergence (PFV) and amplitude of accommodation (AA) before and after introduction of 6 prism base-out (BO) at fixation distance of 6m for 15 minutes**. Methodology:** Thirty participants were recruited in this quasi-experimental study and all of the participants wore the 6 prism BO for 15 minutes while watching movie at 6m. AA and PFV at 6m and 40cm were measured pre- and post-watching movie at 6m with 6 prism BO inducement. **Results:** The AA and PFV before and after intervention were then being compared and the results showed that there were insignificant changes ($p>0.05$) in AA and PFV of both eyes. **Conclusion:** The results suggested that the utilization of 6 prism BO in 15 minutes did insignificantly alter accommodation and vergence system.

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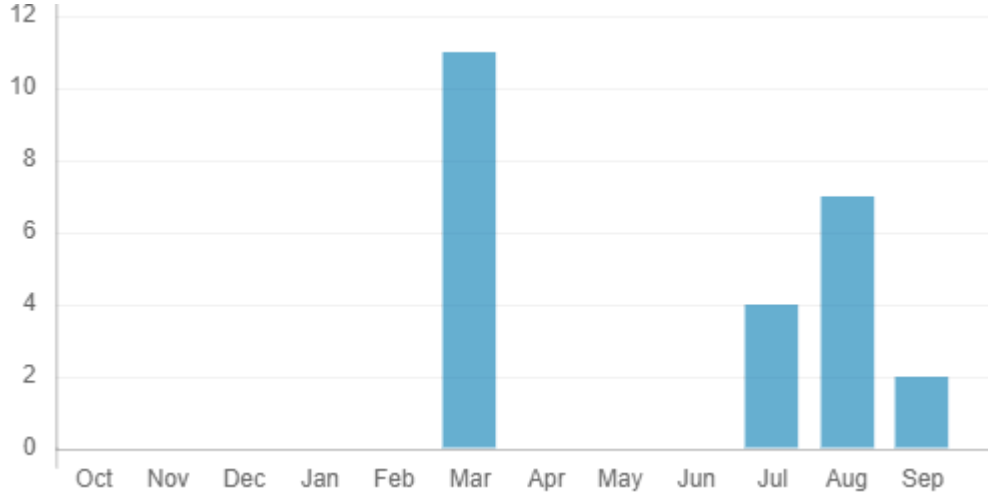

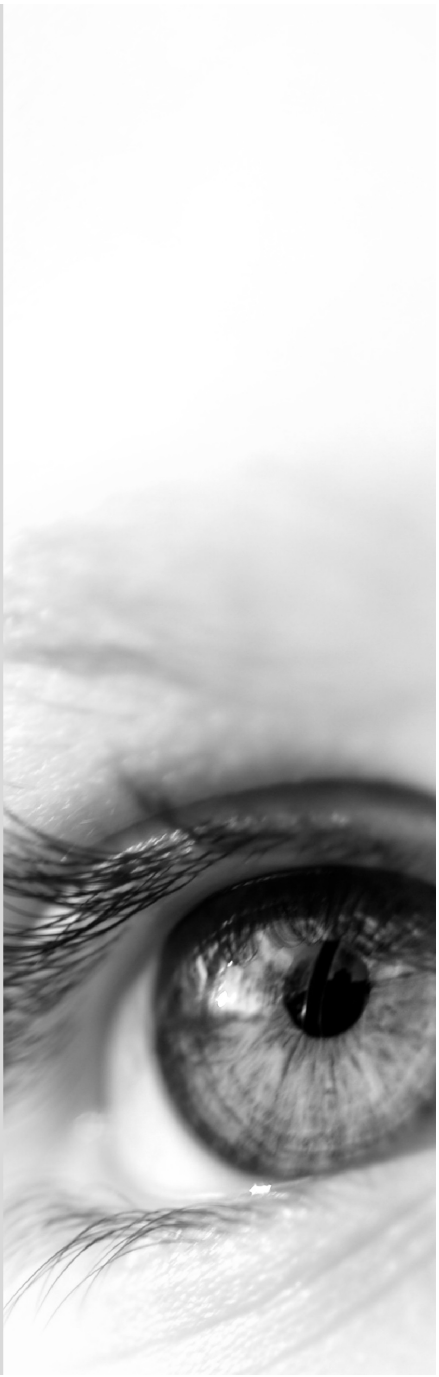

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THE EFFECT OF 6-PRISM BASE-OUT AT 6-METRE FIXATION ON VERGENCE AND ACCOMMODATION SYSTEMS

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ABSTRACT

Introduction: Prisms is used for binocularity diagnosis and vision therapy in optometry particularly in treating symptomatic vision anomalies such as divergence excess, convergence insufficiency, nystagmus and concomitant as well as incomitant strabismus. This utilization of base-out prism in the alteration of vergence and accommodation system is not well explored especially on normal binocular vision. This study aimed to assess the effect of prism base-out inducement on vergence and accommodation among normal binocular vision system. **Aim:** To compare the value of positive fusional vergence (PFV) and amplitude of accommodation (AA) before and after introduction of 6 prism base-out (BO) at fixation distance of 6m for 15 minutes**. Methodology:** Thirty participants were recruited in this quasi-experimental study and all of the participants wore the 6 prism BO for 15 minutes while watching movie at 6m. AA and PFV at 6m and 40cm were measured pre- and post-watching movie at 6m with 6 prism BO inducement. **Results:** The AA and PFV before and after intervention were then being compared and the results showed that there were insignificant changes ($p>0.05$) in AA and PFV of both eyes. **Conclusion:** The results suggested that the utilization of 6 prism BO in 15 minutes did insignificantly alter accommodation and vergence system.

KEYWORDS: Positive fusional vergence (PFV), prism base-out, amplitude of accommodation (AA), visual therapy

INTRODUCTION

Accommodation system is defined as an alteration in the curvature of the crystalline lens which results a dynamic change in the refractive power of the eye (Plainis, Charman, & Pallikaris, 2014). The phenomenon occurs when fixation changes from distance to near or vice versa. During distance viewing, the crystalline lens is thin and when the viewing change to near, the image seen is focused behind the retina, leading to the stimulation of retinal blur. This stimulation results in the increment thickness of the lens to bring the image seen back on the retina (Charman, 2008).

Apart from retinal blur, the accommodation can be stimulated indirectly by retinal disparity and proximal factors (Suryakumar, Meyers, Irving, & Bobier, 2007). Both factors are induced by vergence or disconjugate eye movement, which is the binocular eye movements that are not conjugate due to the lines of sight are rotated towards or away each other (Rashbass & Westheimer, 1961). It can be divided into convergence, which is the eye's ability to turn inward when looking at near and divergence which is defined as the eye's ability to turn outward when looking at distance (Cercenelli et al., 2018).

Motor fusional vergence is one of the vergence eye movement components and defined as the ability to maintain binocular vision through a range of induced disjunctive eye movement (Rowe, 2010). One of the motor fusional vergence test is positive fusional vergence (PFV), which is commonly conducted to measure the strength of convergence. It can be measured by gradually increasing the prism power to create retinal disparities which stimulate both eyes move inward (Sassonov, Sassonov, Koslowe, & Shneor, 2010). The strength of PFV reaches until the diplopia image is perceived during the increment power of prism (Fu et al., 2015). The stimuli to vergence and accommodation are consistent with one another in natural viewing. For example, looking at a farther object requires divergence and a decrease in focal power of the crystalline lens while looking at a nearer object requires convergence and increment in lens focal power. The two responses which are accommodation and vergence are coupled such that changes in vergence induce the same changes in accommodation and vice versa (Kim, Kane, & Banks, 2014). A cross-link in the neural control system that controls the oculomotor adjustments for near and far viewing produce the coupling system between accommodation and vergence (Joohwan, Kane & Banks, 2014). These two ocular systems interact with each other to provide a clear single binocular vision (Suryakumar, 2005).

Prism is a transparent, solid, triangular refracting medium and has two parts which are base and apex. The power of prism is determined by its apical angle. Prism works when light entering the prism and it will deviate toward its base. However, the image appears shifted to the apex. This makes the eye examined or treated tend to deviate toward its apex, (Antony, 2017). When a prism is placed in front of the eye, the disparity between the images of the eyes is stimulated by the vergence system to rotate the eyes in an appropriate direction to achieve fusion (Thiagarajan, Lakshminarayanan, & Bobier, 2010). Sassonov et al., (2010) stated that base-out prism causes a spatial change, leading to the apparent image of the target to recede thereby creating a demand to converge. Prism can be used as a therapy which provide symptomatic relief in many problems such as squints, non-strabismic conditions like divergence excess, convergence insufficiency, and nystagmus (Dell'Osso, 2014; Martínez, Muñoz, & Ruiz-Cantero, 2009). In the condition of prism decentration on spectacle, the disjunctive eye movements that stimulated by prismatic effects place a demand on the fusional vergence systems of the eyes. If the prismatic effect exceeds the capacity of the eyes to maintain comfortable binocular vision, it can result in eyestrain and double vision (Moodley et al., 2011).

There is a latest study suggests a prism base-out therapy used over a 12-14 weeks period can shows significant increases in PFV with improved (reduced) near point of convergence (NPC) for near PFV (Sreenivasan & Bobier, 2015). However, the utilization of prism on distance PFV is not well-explained in the previous investigations. As there were lack of discussion regarding the utilization of prism, this study was suggested to be conducted in Malaysia specifically among International Islamic University Malaysia (IIUM) Kuantan population. The investigation was conducted on normal population and was aimed to assess the effectiveness of 6 prism base-out inducement during watching movie for 15 minutes on the accommodation and distance positive convergence reserve. The increment of PFV was predicted to the normal population after the inducement of the prism. It was also expected to give similar effect on exophoric person.

MATERIALS & METHODS

This study was conducted at the IIUM Optometry Clinic, Kulliyyah of Allied Health Sciences, IIUM, Kuantan, Pahang, Malaysia. The tenets of declaration of Helsinki was adhered and the approval of the study was obtained from the Kulliyyah Postgraduate and Research Committee (KPGRC, ID Number: KAHS 67/81). All subjects were explained thoroughly about the procedure of study. The informed consent form was signed by the subject if he or she agreed voluntarily to participate this study. The inclusion criteria for subjects involving in this study were; healthy (free from ocular and systemic diseases), not taking any medication, aged between 18 to 25 years old, visual acuity at least 6/6 at distance and N5 at 40cm with habitual refractive correction for each eye (spherical range of ±4.00DS and cylinder power up to -2.00DC). Subjects were excluded if they had amplitude of accommodation less than 10 D and more than 13 D, near point of convergence (NPC) of 9cm or less, abnormal phoria value for distance (normal value: 1 esophoria to 2 exophoria) and near (normal value: 0 to 6 exophoria) and abnormal AC/A ratio (normal value: 2 to 6^{Δ}/D).

Grand Seiko WR-5100K Auto Refractor/Keratometer was used to measure the refractive error. The autorefractor has been reported to be accurate and repeatable to subjective refraction (Davies, Mallen, Wolffsohn, & Gilmartin, 2003). The amplitude of accommodation (AA) was measured by using push up and push down method with Royal Air Force (RAF) rule on each eye and the value must be within the range of expected AA by age which was stipulated by Donder's formula.

Next, the normality of vergence system was ensured by the assessment of NPC by RAF rule and heterophoria using Howell Card. In addition, the accommodation facility test was also conducted using the Rock Card and +2.00/-2.00 flipper lens. This was important to measure the flexibility, stamina and dynamic of the accommodation on repetitive stimulation and relaxation of accommodation or when changing focus from distance to near and vice versa (Maxwell, Tong, & Schor, 2012). All of these assessments were performed to ensure the binocular vision's status was normal.

Subsequently, PFV value at distance, which was at 6-metre, were measured by placing the prism bar before the right eye. It started with low prism base-out power, then gradually increasing the amount of prism power until diplopia image was reported by a subject to obtain the value of maximum convergence fusional reserve ability. The prism power was then reduced until single image was seen, which is known as recovery point. Then, 6 prism base-out was worn in front of right eye. Subject was requested to watch English movie titled *Moana* with the prism, which was projected at the screen at 6m for 15 minutes. After 15 minutes, amplitude of accommodation (AA) and PFV at distance were re-measured.

The data was analysed by using Statistical Package for Social Science (SPSS) software (V12.0.1 for Windows; SPSS Science, Chicago, Illinois, USA). Normality test was performed for all data using central limit theorem since 30 subjects were recruited prior to analysation of data. If normality assumption was met, it could be proceeded with paired t-test. Otherwise, Wilcoxon signed rank test could be the alternative test to use. Pre- and post- values of PFV and AA were analysed using either paired t-test or Wilcoxon signed-rank test after 15 minutes watching movie at 6m. Significant level was set at value $p<0.05$ for all tests.

RESULTS

Thirty subjects (8 males, 22 females) with the mean age 23.37 ± 0.85 years were involved in this study. Table 1 shows the comparison between pre- and post-6 prism base-out inducement after 15 minutes watching movie on PFV at 6m, right and left eyes AA. After 15 minutes of distance activity, there was an increment recorded on PFV at 6 m. However, the increment was not significant ($p > 0.05$). The AA was statistically showed insignificant reduced ($p>0.05$) on both right and left side.

Table 1: Comparison table between pre- and post-intervention of prism base-out on PFV and AA.

Description	**Mean ± SD**		***t*-value**	***p*-value**
	Pre-Intervention	Post-Intervention		
RE AA	9.69±1.12	9.29±1.24	1.91	0.066
LE AA	9.82±1.09	9.65±1.33	0.79	0.437
PFV at 6m	20.73±9.53	22.13±9.79	-1.33	0.194

*PFV=positive fusional vergence, RE AA= right eye amplitude of accommodation, LE AA= left eye amplitude of accommodation, SD = standard deviation

DISCUSSION

The 6-prism base-out worn for 15 minutes during watching movie at 6m did not make the prominent changes on the convergence fusional reserve or PFV in this current investigation. Franzén et al., (2000) reviewed that the significant changes could not be seen due to visual fatigue. Sullivan (2008) described that longer duration of visual tasks which also involve vergence and accommodation system muscles might contribute to visual fatigue. The fatigue occurs when one motor system (accommodation or vergence) adapted more readily than the other. This causes an increment of the cross-link interaction originated from the more adaptable oculomotor system and a reduction of the cross-link interaction originated from the less adaptable motor system (Schor & Tsuetaki, 1987). Schor & Tsuetaki, (1987) discovered that the adaptability of these two visual oculomotor systems can be demonstrated by the aftereffects of accommodation and vergence. Visual system fatigue had no long-term harmful effects, thus it was possible to recover from it by rest or change in task. Moreover, Sullivan (2008) found that there were no established bounds on recovery time since the length of this recovery period might vary

significantly depending on the nature of the fatigue. Recovery from the visual fatigue could occur within minutes in some cases (Sullivan, 2008).

Apart from that, the wash out period of increment of PFV after using the 6-prism base-out also need to be concerned. In this present investigation, PFV was measured a few minutes after the task since measurement of AA was carried out first. During these few minutes, the vergence adaptation which could cause the alteration of PFV might wash out. Vergence adaptation will recover within a shorter period (Franzén et al., 2000). Vergence adaptation might also be affected by the visual fatigue as the fatigue would not diminish within a few minutes. This similar situation exists in both accommodation and vergence system (Franzén et al., 2000).

The result of this study was also supported by Schor & Kotulak (1986) which stated that the inducement of convergence could influence accommodation in theoretically even though the AA between pre- and post-intervention of 6 prism base-out for 15 minutes did not change significantly on each eye. Similar to what had been discussed in PFV in above paragraph, the insignificant difference in AA after intervention might be due to fatigue in binocular vision system (Sullivan, 2008).

Future research is suggested to be conducted with higher magnitude of prism diopter which could cause more effective increment in PFV. Moreover, it is better if the subjects could wear the 6-prism base-out for a longer period (about 30 minutes) continuously without fail to observe the outcome of interest.

Furthermore, it is suggested to perform the test at the specific time for all subjects especially at morning. This is to reduce the effect of daytime and fatigue on measurements. However, the more repetitive and quantitative measurement test in the same time might cause the binocular system fatigue (Sullivan, 2008). Thus, for the suggestion of future research, it could be better to conduct one parameter measurement only at one time to avoid visual fatigue. In fact, the measurement of many tests after any intervention of prism could be better if those measurements can be done separately at different visit.

Only the subjects who have a normal binocular vision including the normal range of phoria at distance and near were recruited in this study. As for this, it is also suggested for future to include subjects who has outside normal range of phoria which are exophoria and increase the number of subjects involved in order to evaluate if there are any changes in PFV of exophoric subjects after wearing the prism BO. It will give two different results either it causes an increment of PFV value which might assist in the condition of decompensated exophoria to become compensated exophoria or a reduction in the phoria value until become within normal range of phoria.

CONCLUSION

In conclusion, the 6-prism base-out inducement for 15 minutes during distance fixation did not make significant impact on positive fusional vergence at 6m and accommodation system among subjects with non-binocular vision anomaly. It is hoped that this study can be carried out further in the future to add and expand more knowledge on the impact of binocular vision system during prism inducement wear as recommended and suggested in this study.

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