

**THE EFFECT OF 6 PRISM BASE-OUT DURING SMARTPHONE USE ON NEAR VERGENCE AND  
ACCOMMODATION SYSTEMS**

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**ABSTRACT:**

**Introduction:** Prism is used in binocular vision assessment and visual therapy. The short-term use of prism, particularly base-out prism on vergence and accommodation system, was not well-explained in the previous investigations. **Aim:** This current study aimed to assess the effect of 6 prism base-out for 15 minutes on vergence and accommodation system during the utilization of smartphone. **Methodology:** Thirty normal participants were recruited in this quasi-experimental study. All participants wore 6 prism-base out for 15 minutes while using smartphone at 40cm. Near positive fusional vergence (PFV) and amplitude of accommodation (AA) were measured before and after 15 minutes of 6 prism base-out wear during smartphone usage. **Results:** The results showed no significant difference for both parameters measured when comparison was made between before and after prism base-out inducement in front of eye. **Conclusion:** The vergence and accommodation systems presented in this study were almost identical among normal subjects after inducement of 6 prism base-out for 15 minutes during watching smartphone.

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

**INTRODUCTION**

Prism is an optical property that causes the light deviates towards its base. As a result, image perceived and the eye which the prism is placed, are shifted towards the apex. For instance, base-out prism leads to the rays of light deviates towards the temporal retina, and the seen image through the prism is deflected to the apex. The changing of light direction in prism is useful for various purposes such as enlarging the visual field for patients with temporal visual field defects (Bowers et al, 2008; Neill et al., 2011), treatment for binocular vision anomalies, i.e decompensated phoria, microtropia, concomitant and incomitant squint, as well as nystagmus (Dell'Osso, 2014; Martínez, Muñoz, & Ruiz-Cantero, 2009). Besides, this ophthalmic lens is heavily used in the binocular vision assessment such assessments of heterophoria, heterotropia, and fusional vergence (Shainberg, 2010).

Fusional vergence is the ability to maintain binocular vision. It can be measured by placing the low prism dioptic in front of the eye, then increase the dioptic until a point that the first diplopia image is perceived. The point is an indication of interruption of binocular vision, known as maximum fusional reserve point. (Fu et al., 2015). Sheard's stated that the fusional reserve should be at least twice the demand (Lanca & Rowe, 2016). Thus, the positive fusional reserve (BO) should be at least twice the amount of the exophoria. The goal for positive fusional vergence (PFV) training is to improve convergence ability which can be observed through parameters like positive fusional vergence (PFV), near point of convergence (NPC) and near exophoria (Preethi Thiagarajan, Lakshminarayanan, & Bobier, 2010). In addition, the alteration of vergence can lead to disruption of accommodation.

Accommodation is a process by which the dioptic power of the eye's crystalline lens is altered according to the vergence of the object to render a clear focused image on the retina (Charman, 2008). When focusing a near object, theoretically the eyes will work on near triads which are accommodation, convergence and pupil constriction (Plainis, Charman, & Pallikaris, 2014). Any abnormalities of accommodation can lead to binocular and accommodative problems. As the short-term inducement of prism before the eye on vergence and accommodation system was not well-explained in the previous investigations, especially on the utilization of advance gadget like smartphone, hence, this study aims to assess the usefulness of 6 prism base-out inducement during watching smartphone for 15 minutes on vergence and accommodation system.

**MATERIALS AND METHODS**

The current investigation was conducted at Department of Optometry and Visual Science, Kulliyah of Allied Health Sciences (KAHS), International Islamic University Malaysia (IIUM), Kuantan district, state of Pahang, Malaysia. The study design was quasi-experimental and the subjects were recruited via convenient sampling. This investigation conformed to the tenets of the Declaration of Helsinki involving human subjects, and the study procedures were approved by the Kulliyah Postgraduate and Research Committee (KPGRC, ID Number: KAHS 70/18). The participation in this study was voluntary basis. Subjects were briefed about the study and if the agreement was achieved between both parties, they were required to sign the consent form before participating in the study. The visual acuity (VA) of subjects should be at least or better 6/6 with habitual correction. This was to consider that any process of accommodation occurred in normal condition. Besides, the refractive error should be within  $\pm 4.00$  D and the cylindrical refractive component cannot exceed  $-2.00$ DC. Subjects should have normal binocular function at distance and near with normal distance (normal value: 1 esophoria to 2 exophoria) and near phoria (normal value: 0 to 6 exophoria), normal accommodative convergence-accommodation (AC/A) ratio (normal value: 2 to 6  $\Delta$ /D) and TNO test of 60 seconds of arc or better. Any accommodation dysfunction will be excluded because it might alter any significant association between smartphone use and accommodation. As the study will be conducted on healthy young adults, any participant must be free from ocular and systemic diseases because some disease may affect the accommodation (Buncic, 1999)

Pre-assessment procedure such as visual acuity, refractive error, accommodation status, phoria assessment and positive fusional vergence were measured. Grand Seiko WR-5100K Auto refractor/keratometer was used to measure the refractive error. Binocular vision assessment was assessed utilizing TNO test for stereopsis, cover test and Howell card for evaluating the status of heterophoria at 6m and 40cm. Subjects were excluded if the results of pre-assessment procedures were abnormal.

The amplitude of accommodation test was conducted using Royal Air Force (RAF) rule by push-up and push-away method. The fixation target used was N5 word size. Subject was asked to fixate the target and subsequently, the target was slowly moved closer to the eye until the first sustained blur is reported. Then, the target was moved away until the subject reported first clear image obtained. The point of first sustained blur and first clear image obtained were recorded as dioptre (D). The procedure was repeated another two times to obtain the mean. The mean point of first sustained blur was taken for the data analysis.

Positive fusional vergence (PFV) values was measured during fixating a target of N5 letter size at 40cm. Prism bar was used and the low prism base-out dioptre was placed before right eye. Subsequently, the prism dioptre was slowly increased until the diplopia image of the fixation target was perceived. The diplopia image is known as break point of PFV. Then, the prism dioptre was reduced until first clear and single image was seen, which is known as recovery point of PFV. The findings were recorded, but however, only the break point was used for the data analysis.

Next, the subject was required to play games (Kiloo: Subway Surf) using Vivo V3 with screen size of 5.5 inch and 1080 x 1920pixels of display resolution. The brightness of the screen was set at half to avoid discomfort glare. The 6prism base-out was placed before the right eye and he or she played the smartphone games with the prism inducement for 15 minutes. Finally, the AA, as well as PFV at 6m and 40cm were re-measured to assess the effect of the inducement during playing smartphone games.

This study was represented in quantitative manner. The data was analysed by using Statistical Package for Social Science (SPSS) software (V12.0.1 for Windows; SPSS Science, Chicago, Illinois, USA). Significant level was set at value  $p < 0.05$  for all tests. Differences in positive fusional vergence (PFV) were compared using Paired t-test or Wilcoxon signed-rank test. Normality test was performed for all the 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. In this study, 30 subjects were recruited; hence Central Limit

Theorem was applied. Paired *t*-test was performed instead of Wilcoxon signed-rank test as normality assumption was met (Chang, Huang, & Wu, 2006).

## RESULTS

Thirty subjects (8 males, 22 females) with age ranged from 22 to 25 years old with mean age of 22.83 and standard deviation (SD) of 0.79 were involved in this investigation.

Table 1: Comparison table between pre- and post-intervention of prism base out on positive fusional vergence (PFV) and accommodation.

Description	Mean (SD)		t	p-value
	Pre-	Post-		
PFV at 40cm	28.07 (9.30)	29.93 (9.70)	-1.62	0.117
RE AA	9.87 (1.38)	10.22 (1.60)	-1.70	0.101
LE AA	10.45 (1.63)	10.67 (1.65)	-1.53	0.136

\*PFV=Positive Fusional Vergence, RE AA= Right eye accommodation, LE AA= Left eye accommodation

Paired *t*-test analysis showed that all the *p*-values for refractive error of both eyes were  $>0.05$ , indicated that there was no significant difference in PFV and AA before and after playing games on smartphone for 15 minutes by using 6 prism BO. Table 1 shows the significance levels and the difference pre- and post-intervention from this study. In spite of showing an increment on AA for both eyes, the difference did not demonstrate statistically and clinically significant ( $p > 0.05$ ). The similar trend was also depicted in the changes of PFV at 40cm ( $p > 0.05$ ).

## DISCUSSION

The goal for prism base-out inducement for 15 minutes is as a training to improve convergence ability which can be observed through parameters like positive fusional vergence (PFV), near point of convergence (NPC) and near exophoria (Thiagarajan, Lakshminarayanan, & Bobier, 2010). The efficacy of prism therapy is observed in few studies, one is from a research made by Cooper et al., (1983) on the effect of positive fusional vergence training for symptomatic convergence insufficiency patient. The research revealed that at the completion of training, patients had reduced symptoms and there is an increase in positive fusional vergence range. Another research is done by Thiagarajan, Lakshminarayanan, & Bobier (2010) in which prisms is used as tool in orthoptic therapy for positive fusional vergence training. The prism is placed in increasing strength where the patient began the therapy with prisms of moderate strength, small enough so that the patient is able to overcome them, then strength of prism will be slowly increased. This exercise increased the convergence and fusional reserve, and they also increase the individual's ability to cope with his phoria for the patient to be able to read and do other near work with greater comfort.

In this study, it was found that the values of PFV did not significantly change after the inducement of 6 prism base-out for 15 minutes during smartphone work. Conversely, Thiagarajan et al (2010) discovered that the PFV was increased significantly after the utilization of prism base-out at near. Eleven 11 normal, healthy, and emmetrope subjects were recruited. The power of prism used in the respective study was 12 prism base-out and was used for near viewing. The participants underwent a vergence training program for a two weeks period, which comprised a total of six sessions (three sessions per week). The training was designed from clinical protocols that served to increase PFV limits. The basis of the training was much like having a subject view through a series of base out prisms of increasing magnitudes. Each session lasted for 25 to 30 min, and each participant had a total of ~180 min of training.

Since the higher prism base-out power used and the longer duration of the prism utilization applied in Thiagarajan and co-worker investigation, the increment on PFV might be demonstrated in the respective study. In current study, the same effect of significant increment in PFV could not be observed. This could be due to only one session is provided for one subject with 15 minutes allocation, using one fixed prism (6 BO) at 40cm value. Despite there is improvement in PFV for most of the subjects, the value was not statistically and clinically significant. The insignificant results could be because of immediate measurements after prism inducement. Since all the measurements were conducted immediately after the exercise and it involves the response of the accommodation system, perhaps the subsequent rapid changes in stimuli from the test combined with the adaptive state of the tonic accommodation due to the exercise masked the changes of the parameters (Schor, 1986).

Since the alteration of convergence can lead to the changes of accommodation due to similar nerve pathway, which is cranial nerve III, accommodation was also measured in this current study (Tousignant, 2017). It was because the utilization of prism base-out leads the changes of convergence system, thus resulting in the alteration of accommodation. AA was a parameter to be chosen because it measures the maximum ability of the ciliary muscle (Ruggeri et al., 2016). Similar to PFV finding, the AA also did not change significantly between pre and post 15 minutes 6 prism base-out inducement for right eye. The trend was also depicted on the left side. These findings were in line with Brautaset & Jennings, (2006). They found that the monocular AA did not significantly change among convergence insufficiency patients after the prism base-out placed before the eyes as an orthoptic treatment. Therefore, pertaining to this discussion, it can be postulated that the utilization of prism base-out for convergence inducement might not affect the accommodation system indirectly.

Future research may be continued with longer period time of prism induced in front of the eye, and with a larger sample size. Other suggestions are by recruiting convergence insufficiency subjects themselves to see how much the improvement is after inducement of prism base out. A study made by Razavi, Sagheb, Poor, & Daneshyar, (2010) suggested that tests performed was advised to be performed in the morning, in the range of 9am to 11am to reduce the effect of fatigue on measurements.

## CONCLUSION

In conclusion, 6 prism base-out wear for 15 minutes did not affect vergence and accommodation systems. Thus, it could be suggested that the decentration of spherical lenses up to 6 prism base-out value might be beneficial to be worn up to 15 minutes. Besides, the prism therapy worn could be insufficient for the respective duration.

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