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Prism vergence measurements following adaptation to a base out prism

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Abstract

This study examines the effect of adaptation on the prism vergence range following an induced deviation. Five young adult subjects, with normal binocular functions, underwent fusional vergence testing to base in prisms before and after wearing a 10^{Δ} base out Fresnel prism. The Fresnel prism was worn for a period of 2, 5 or 10 min on each of three separate occasions. The base in fusional vergence showed no statistical difference before or after adaptation, for any of the time periods. Also there was no difference in the ranges obtained over the three time periods. It was concluded that, even after a 2 min period of adaptation, fusional vergences return to a similar level as before the horizontal deviation was induced.

Key words: Prism vergences, Prism fusion range, Vergence adaptation, Phoria adaptation

Introduction

The vergence system can adapt to prism-induced phorias.[1–3] When a vertical or horizontal prism is placed in front of the eye(s), the resultant deviation gradually reduces provided binocular viewing is allowed. This tends to occur more quickly with base out prisms than base in. The reduction towards the baseline measurement is not totally complete and tends to saturate.

Henson and North[1] reported that, when a 6^{Δ} vertical prism was used to induce a deviation, adaptation was substantially completed after 2–3 min of binocular viewing. With small prisms, there is a small residual deviation (1^{Δ} or less), but the rate of adaptation decreases where larger prisms are used.[3]

Schor[4] suggests that in response to a prism in front of one eye, there is a system which initially realigns the eyes – the fast fusional system (phasic). The output of this system then acts upon a slow fusional system (tonic), which adapts to the fusional demand.

Sethi and Henson[5] have suggested that there are two stages to adaptation. Firstly, there is the immediate temporary stage in which the oculomotor system changes the eye position back to the baseline phoria with a rapid change back when the disparity is removed. Secondly, there is the sustained permanent stage where, following adaptation, there is a slow change back to the original phoria and the ability to deal with any further vergence disparity will be as normal.

Carter[6] in 1963 reported one subject who was gradually adapted over several weeks to base in prisms of increasing size up to 9^{Δ}, and in whom the base in range remained within 2^{Δ} of its original value. In a later paper[7] Carter examined heterophoria measurements following adaptation to horizontal prisms ranging from 10^{Δ} base in to 32^{Δ} base out. The prisms were increased gradually, with a 15 min adaptation period being allowed with each increase. The residual deviation was 'not greater than the random variation expected with heterophoria measurements'. Most of the adaptation occurred within the first 5 min of wearing the adapting prism. He also found similar fixation disparity curves to forced convergence and divergence before and after 15 min of adaptation.

Stephens and Jones[8] found that fusional amplitudes were relatively unaffected by vergence adaptation in normal subjects, except at the largest values of adapting prism. The size of adapting prisms started at 2^{Δ} in front of either eye and 10 min was allowed for adaptation to occur; prisms were then increased in 2^{Δ} steps up to 20^{Δ}, and in 5^{Δ} steps after this until the limit of fusional vergence was reached. Base out prisms and base in prisms were each used on different days to complete the experiment.

This study was designed to investigate the effect of adaptation on fusional vergences over three different time periods of adaptation.

Methods

Young adult subjects between the ages of 18 and 25 years were recruited. Informed consent was obtained. Criteria for inclusion were: corrected visual acuities of 6/6 either eye; heterophoria of less than 6^{Δ}; binocular single vision on Worth's lights; stereo-acuity of 55 seconds of arc or better (Frisby stereotest); and a minimum prism fusion range of 10^{Δ} base out to 10^{Δ} base in at 6 m. Each subject was required to attend on three separate occasions.

At each visit the subject was asked to fixate a 6/6 Snellen letter at 6 m. The base out and base in fusional vergences were measured to blur point, or break point if blur was not appreciated, in 2^{Δ} steps. This was performed by increasing the prism in front of the left

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eye up to 20^{Δ} and then introducing a bar in front of the right eye and increasing the prism in 2^{Δ} steps. If higher strengths of prism were needed one bar was reduced in strength whilst the second bar was increased to compensate for the change, and 2^{Δ} steps again used. The order of testing base out and base in was randomised.

Provided the subject fulfilled the above criteria, they were either asked to wear a pair of plano glasses with a 10^{Δ} base out Fresnel prism on the right lens, or the prism was placed on the right lens of the subject's current glasses. This was worn for a period of 2 min, 5 min or 10 min. The time order was assigned on a random basis. During the time that the subject was wearing the prism they were asked to maintain fixation at 6 m in the primary position. At the end of the given time period, the base in prism vergence range was measured following the same procedure as above, with the Fresnel prism in place.

No correction was made for the splitting of prisms between the eyes[9] or for the use of the Clement Clarke prism bar being held in the frontal plane, as the method of testing was the same in the two situations being compared (i.e. pre- and post-adaptation).

Results

Five subjects, mean age 20.2 ± 1.2 years, participated. Results are given in Table 1.

The mean base in vergence ranges are shown in Fig. 1. A paired *t*-test was used to compare the prism vergence range before and after adaptation at each visit. No difference was found before and after 2 min of adaptation ($p = 0.3046$), 5 min of adaptation ($p = 0.1890$) or 10 min of adaptation ($p = 0.3739$).

An analysis of variance was used to examine the effect of time allowed for adaptation on the base in vergence range. This showed no significant difference between the adaptation periods for base in vergences ($p = 0.7687$).

Table 1. Base in prism vergence range (prism dioptres) before and after prism adaptation for 2, 5 and 10 min

	Period of adaptation					
Subject no.	0	2 min	0	5 min	0	10 min
1	8	6	12	12	12	12
2	10	8	12	6	6	6
3	4	4	8	8	6	8
4	14	16	6	2	2	2
5	12	8	6	6	4	4
Mean	9.6	8.4	8.8	6.8	6.0	6.4
Standard deviation	3.85	4.56	3.03	3.63	3.74	3.85

Discussion

The results here agree with those of Carter[6,7] and Stephens and Jones[8] and show that there was no change in the base in prism vergences following the wearing of the 10^{Δ} prism.

In a study where no difference is found it may be questioned as to whether 5 subjects are sufficient. In this study, however, a difference of 10^{Δ} would be expected if no adaptation had occurred. Assuming a population standard deviation of 4, power calculations show that for power = 0.99, a difference of 7.6^{Δ} between the means of results before and after the period of adaptation would have been found. If partial adaptation had taken place a difference could occur, but even looking for a difference of 5^{Δ} between means, power = 0.80. (The choice of a population standard deviation of 4 could be considered

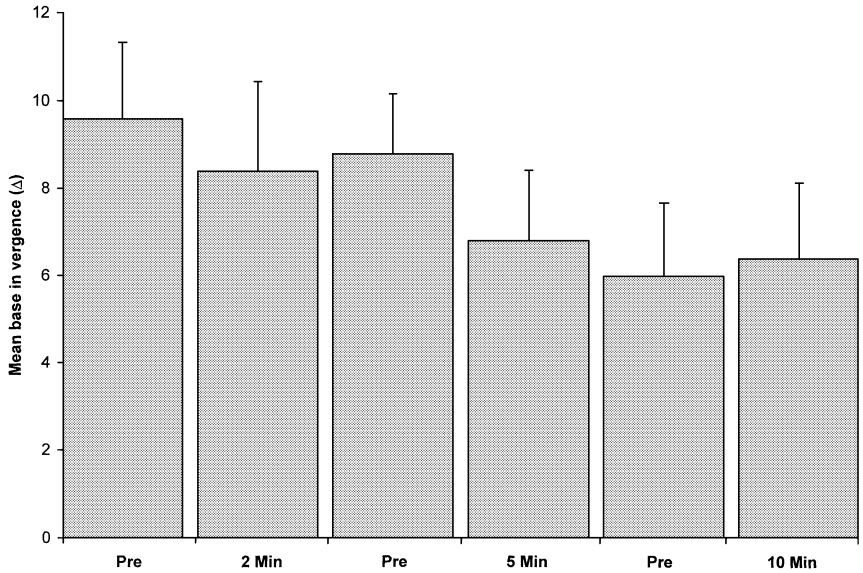

Fig. 1. Mean and standard error bars of base in fusional vergences at each of three visits, before and after a period of adaptation (2 min, 5 min, 10 min). Order of the time periods for adaptation was randomised.

as conservative, as lower standard deviations for the distance base in fusion range have been reported.[10])

There appears no difference in the results following the different time periods and this suggests that adaptation has reached the sustained permanent stage described by Sethi and Henson,[5] even after a 2 min period. It has been suggested that adaptation begins to occur 1 s after viewing through base out prisms.[11] Henson and North[1] found that adaptation to a prism-induced phoria was substantially completed after only 2–3 min of binocular viewing. They reported that the speed of adaptation to a 6^{Δ} base out prism was slightly faster than to a 6^{Δ} base in prism. A significant correlation between gain of adaptation for vertically induced phorias and amplitude of vertical fusional vergences has been reported[12] and this is probably also so for horizontal disparities.

Rosenfield *et al*.[13] demonstrated an effect of adaptation to base out testing in that the base in recovery point became less. However, they found no statistical difference in the break points with order of testing, and comment that it is not known how changing disparities affect the range. When exercising a fusion range clinically, it is possible that some adaptation is allowed and may be responsible for the improvement seen during the exercise, if adaptation is normal.

Abnormal adaptation has been reported in patients with symptom-producing heterophoria and convergence insufficiency,[3] although it has been disputed as to whether this is the cause of symptoms.[14] Subjects undergoing treatment can show an improvement – suggesting that not only the fast fusional vergences are improved but also the slow fusional vergences.[3] However, improvement may not go hand in hand and the fusion range may be normal but prism adaptation abnormal. Subjects whose prism adaptation does not improve with therapy, remain symptomatic but may be helped by prismatic corrections.[3] There has also been a suggestion that asymptomatic individuals may reach the maximum degree of adaptation quicker than symptomatic subjects.[15]

This study lends further support to the recommendation by North and Henson[3] and Rosenfield *et al*.[12] that, when measuring the fusion range clinically, it may be of more benefit to test the range which compensates for the patient's phoria first, in order that the result is not biased by adaptation artefacts from a previously tested range.

Conclusion

The results of this study show that similar fusional vergences are obtained before and after periods of adaptation of 2 min, 5 min and 10 min to a 10^{Δ} base out prism.

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