
This study examined the vergence adaptation that occurred after vergence range testing and vergence facility testing and sought to find whether the magnitude of vergence adaptation was correlated with vergence range or vergence facility findings. The investigators also looked at whether there was a correlation between vergence range and vergence facility results.

The thirty subjects ranged in age from 23 to 35 years. They all had 20/20 visual acuity in each eye either with or without contact lens prescription, no strabismus or amblyopia, and no previous vision therapy. They underwent three testing sessions: (1) base out prism bar vergence ranges to blur, break and recovery, with a 20/30 vertical row of letters at 16 inches; (2) vergence facility for one minute with 12Δ base out / 3Δ base in flippers; and (3) viewing a video on a computer monitor through 6Δ base out prisms for five minutes.

The values recorded for vergence ranges were the amounts of prism taken from the phoria position instead of the usual manner of clinical recording of findings taken from the target vergence demand. For subjects who did not report a blur, the break finding was used as the blur in the analysis.

Dissociated phorias were measured before and after each testing session using the modified Thorington test. The change in the phoria was taken to be a measure of the vergence adaptation occurring due to the testing procedures.

The average changes in phoria for each testing session were in the eso direction. The mean changes were: after BO vergence range testing, 3.7 prism diopters (SD=2.5); after vergence facility testing, 3.3 prism diopters (SD=1.6); and after viewing through 6Δ BO prism, 2.8 prism diopters (SD=1.6). Differences in the amount of vergence adaptation between these three conditions were not statistically significant.

The Spearman rank correlation coefficient of BO blur with amount of vergence adaptation induced by vergence range testing was not statistically significant (r=0.25; p=0.18). However, the Spearman correlation coefficient between BO break and amount of vergence adaptation induced by vergence range testing was significant (r=0.45; p=0.013). The Spearman correlation of vergence facility with amount of vergence adaptation induced by vergence facility testing was not significant (r=-0.30; p=0.11).

Based on the results, the authors suggested the following: (1) Because vergence ranges and vergence facility did not correlate, vergence facility testing may be advisable in patients with asthenopia but normal vergence ranges. (2) The BO break may correlate with amount of vergence adaptation while the BO blur does not, because patients maintain fusional vergence for a longer period of time for the break finding than for the blur. (3) The lack of correlation of BO blur with vergence facility cannot be attributed...
to vergence adaptation because neither BO blur nor vergence facility correlated with amount of vergence adaptation.


This paper reported a variety of measures of accommodative function in 12 persons, ages 18 to 40 years, with near vision symptoms and a history of mild traumatic brain injury. Test procedures were performed in the following order: (1) lateral and vertical near von Graefe phorias in the phoropter; (2) lens rock accommodative facility with +1/-1 D flippers and 20/30 letters at 40 cm; (3) tonic accommodation measured with a WAM 5500 open field autorefractor in near darkness after subjects relaxed and imagined looking into the distance for three minutes; (4) dynamic monocular accommodative changes over two minutes in response to changes in fixation from 20/30 letters at 50 cm (2 D accommodative stimulus) to a 20/60 word at 25 cm (4 D accommodative stimulus) measured with the WAM 5500 autorefractor; (5) slope of accommodative response as a function of accommodative stimulus, using accommodative responses measured monocularly and then binocularly with the WAM 5500 autorefractor, with reduced Snellen letters at distances corresponding to accommodative stimulus levels of 2 D, 2.5 D, 3 D, 4 D, and 5 D; (6) push-up amplitude of accommodation in free space using 20/30 letters on a reduced Snellen chart; (7) minus lens amplitude of accommodation in the phoropter done monocularly with 20/30 reduced Snellen letters at 40 cm; (8) NRA and PRA in the phoropter with 20/30 reduced Snellen letters at 40 cm; (9) stimulus AC/A ratio determination by linear regression of phoria on accommodative stimulus, using phoria measurements in the phoropter taken with varying lens powers resulting in accommodative stimulus levels of 1.5 D, 2.5 D, 3.5 D, and 4.5 D; (10) +1/-1 D lens flipper test taken as a pre-fatigue measurement; (11) three minutes of alternating lens flippers to attempt to induce fatigue; and (12) repeat of lens flipper test as a post-fatigue measurement.

For most tests, the results were compared to established norms. For tests 2, 3, 4, and 5 in the list above, results were compared to a visually normal control group of ten persons. Persons in the control group did not have a history of traumatic brain injury, accommodative dysfunction, or vergence dysfunction, and they ranged in age from 22 to 35 years.

The results from the study were as follows (numbered corresponding to the list of test procedures above):

(1) In the test group of 12 persons with mild traumatic brain injury, seven had near lateral phorias outside the range of ortho to 6Δ exo considered to be normal in Morgan's norms. Five showed esophoria and two had exophoria greater than 6Δ. Five of the twelve had non-zero vertical phoria measurements, with none of the five vertical phorias being over 2Δ.

(2) Lens flipper rates in the test group were: right eye, 15.2 cpm (standard error=1.9); left eye, 14.6 cpm (SE=1.8); and both eyes, 15.3 cpm (SE=1.4). The rates in the control group were: right eye, 16.1 cpm (SE=1.2); left eye, 16.0 cpm (SE=1.2), and both eyes, 15.6 cpm (SE=1.2). The difference between groups was not statistically significant.

(3) Tonic accommodation averaged 0.16 D (SE=0.21) in the control group and 0.60 D (SE=0.43) in the test group. An unpaired t-test did not show a statistically significant difference, but it appeared that there was more variability in tonic accommodation in the brain injury group.

(4) The dynamic accommodation measurements showed differences in peak velocity of change in accommodative response between the test group and the control group (p<0.001). The peak velocity for increasing accommodation averaged 5.1 diopters per second (SE=0.6) in the test group and 8.0 D/sec (SE=0.4) in the control group. Mean peak velocities for decreasing accommodation were 6.1 D/sec (SE=0.5) in the brain injury group and 8.0 D/sec (SE=0.4) in the control group.

(5) Slope of monocular accommodative response as a function of accommodative stimulus averaged 0.87 (SE=0.03) in the control group and 0.78 (SE=0.04) in the brain injury group. Mean slopes for binocular measurements were 0.83 (SE=0.04) in the control group and 0.81 (SE=0.04) in the test group. A one-way ANOVA did not show a statistically significant difference.

(6) Mean push-up amplitude of accommodation findings in the brain injury group were right eye, 6.63 D; left eye, 6.38 D; and both eyes, 7.15 D. Mean normal age-matched values from Duane were 8.23 D.
for monocular amplitude and 8.69 D for binocular amplitude. The difference was statistically significant.

(7) Minus lens amplitude of accommodation averaged 4.31 D in the right eye of test subjects and 4.65 D in the left eye. Five of the twelve had a difference between the two eyes of at least 1.0 D.

(8) In the brain injury group, the NRA averaged +2.23 D (SE=0.27). The mean PRA finding was -2.23 D (SE=0.52). Three of the twelve had low values for both NRA and PRA according to Morgan’s norms, two others had a low PRA but normal NRA, and one other had a PRA which was normal but more than 1.0 D less than the NRA.

(9) The authors considered the normal range on the stimulus AC/A ratio to be 2 to 6 Δ/D. A stimulus AC/A ratio was not obtained for one of the twelve subjects. The AC/A ratio was greater than 6 Δ/D in two subjects and less than 2 Δ/D in three subjects. Thus the stimulus AC/A ratio was outside the normal range in nearly half (five of eleven) of the subjects.

(10-12) The mean pre-fatigue flipper rate in the brain injury group was 16.3 cpm (SE=1.1). The mean post-fatigue rate was 13.8 cpm (SE=1.0). A paired t-test showed a significant difference (p=0.004). They noted that the literature suggests that fatigue would not have been predicted for a normal group.

Based on the tests where the authors saw differences between the brain injury group and either control group findings or norms from the literature, they suggested that the tests most likely to assist in the detection of an accommodative problem in patients with mild traumatic brain injury are amplitude of accommodation, fatigue on lens flippers, stimulus AC/A ratio, near lateral phoria, and NRA/PRA.

The authors observed that “accommodative dysfunction may be especially prevalent in the mTBI population … Symptoms of accommodative deficit, such as blur, intermittent diplopia, and near work asthenopia, could negatively affect reading ability (a primary problem in mTBI), ambulation, driving, and visual detection/discrimination tasks … Fortunately, these accommodative dysfunctions can be successfully remediated … with relatively simple optometric vision therapy paradigms … and/or the prescription of low-powered plus lenses for near work.” (p. 196)

In this study, the authors examined the microfluctuations that occur in accommodation when it is recorded continuously over a short period of time of a few seconds. Some previous studies have reported greater accommodative microfluctuations in subjects with myopia than in subjects with emmetropia. This study was undertaken to examine the effects of plus and minus adds on variability of accommodative response in children with myopia and children with emmetropia.

Subjects in this study were between 7 and 14 years of age. They had astigmatism less than 1 D, anisometropia less than 1 D, best corrected visual acuity of at least 6/6 in each eye, no strabismus, and normal amplitudes of accommodation. Subjects in the myopia group had cycloplegic refractions of -0.75 to -6 D, and those in the emmetropia group had cycloplegic refractions ranging from +0.25 to +1.5 D. There were 28 subjects in the myopia group and 25 subjects in the emmetropia group. They also classified subjects into normal phoria (0 to 4Δ exo), exophoria (>6Δ exo), or esophoria (>2Δ eso) categories based on the modified Thorington test.

Accommodation was measured with a PowerRefractor infrared photorefractor while subjects viewed a color cartoon on a liquid crystal monitor at a distance of 33 cm. Accommodative response was sampled 25 times per second over a five second period of time. These measurements were taken with monocular viewing conditions and binocular viewing conditions at each of three sessions. At one session testing was performed with subjects wearing distance refractive corrections. The other two sessions involved testing with +2 D and -2 D lens adds. With the test distance and add powers used, the accommodative stimuli for the three sessions were thus 1.0, 3.0, and 5.0 D. Variability in accommodation was defined as the standard deviation of the accommodative response taken during each five second test period.

Accommodative variability in the no add condition was greater in the myopia group than in the emmetropia group. This was true for both monocular and binocular viewing, and it was true within each of the phoria categories. Mean variability for the no add condition was about 0.35 D in the myopia group and 0.23 D in the emmetropia group.

The +2 D add reduced accommodative variability in the myopia group but not in the emmetropia group. With the +2 D add, accommodative variability was not significantly different in the myopia group

(average variability, 0.19 D) from that in the emmetropia group (average variability, 0.20 D).

The -2 D add increased accommodative variability in both the myopia group and the emmetropia group. With the -2 D add, the average variability was greater in the myopia group (0.53 D) than the emmetropia group (0.40 D).

Accommodative response findings were also reported in the paper. Accommodative response was statistically significantly less in the myopia group than in the emmetropia group for the no add (myopia, 2.08 D; emmetropia, 2.34 D) and -2 D add (myopia, 3.27 D; emmetropia, 3.63 D) conditions, but not in the +2 D add (myopia, 0.98 D; emmetropia, 1.12 D) condition.

Accommodative variability showed a statistically significant correlation with accommodative error (defined by the authors as accommodative stimulus minus accommodative response), such that greater accommodative variability was related to greater accommodative error. The authors noted that one of the significant results of the study was that correlation of accommodative variability with accommodative error. It would be interesting to know how accommodative variability might change with a range of different plus adds. It would also be interesting to know whether the add that reduced accommodative variability to a minimum would show a correlation with the plus add power recommended by clinical tests.