Article • Vertical Heterophoria Treatment Ameliorates Headache, Dizziness and Anxiety

Debby L. Feinberg, OD • NeuroVisual Medicine Institute • Bloomfield Hills, Michigan

Mark S. Rosner, MD • St. Joseph Mercy Hospital • Ypsilanti, Michigan

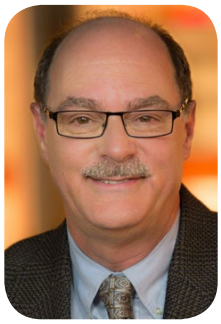
Arthur J. Rosner, MD • The Oakland University William Beaumont School of Medicine Rochester, Michigan

Debby L. Feinberg, OD
Bloomfield Hills, Michigan

Director of Clinical Care and Education, NeuroVisual Medicine Institute

Illinois College of Optometry, 1983

University of Michigan, BS, 1979



Mark S. Rosner, MD
Ypsilanti, Michigan

Director of Education and Research, NeuroVisual Medicine Institute

Emergency Medicine, Henry Ford Hospital, Detroit, Michigan, 1983-1986

University of Michigan Medical School, 1983

University of Michigan, BS, 1980

ABSTRACT

Background: Vertical heterophoria is known to cause headache, dizziness, and anxiety, three commonly comorbid diseases. Earlier studies have shown that correction of vertical heterophoria smaller than the standard error of existing phoria tests can reduce symptoms. This study is designed to demonstrate the effectiveness of prism lenses correcting for small amounts of vertical heterophoria in reducing symptoms in patients presenting with headache, vestibular and/or anxiety symptoms, and also to demonstrate effectiveness of micro-prism lenses to diagnose vertical heterophoria.

Methods: Retrospective study of patients diagnosed with vertical heterophoria who responded to treatment with micro-prism lenses and completed survey instruments at an optometry clinic in Michigan, USA. This study included 111 patients presenting with vertical heterophoria symptoms between 07/2009 and 06/2011 who self-reported significant disability from headache, dizziness, and/or anxiety on the Headache Disability Inventory, Dizziness Handicap Inventory, and Zung Self-Rating Anxiety Scale respectively, and completed pre- and post-treatment survey instruments. Participants were treated by application of corrective micro-prism lenses (vertical prism 0.25D-2.50D) followed by 1-3 lens prescription adjustments over 8-12 weeks. Outcomes were measured by repeating survey instruments.

Results: Mean HDI score reduced from 37.55 to 22.13, effect size d = .54. Mean DHI score reduced from 38.01 to 18.68, effect size d = .72. Mean SAS score reduced from 42.13 to 34.22, effect size d = .80. No side effects reported.

Conclusions: Screening and treatment for vertical heterophoria using micro-prism lenses provided significant symptom relief for patients with headache, dizziness, and anxiety symptoms that had not responded to traditional treatments.

Keywords: anxiety, binocular vision dysfunction, dizziness, headache, micro-prism, vertical heterophoria

Introduction

Headache, dizziness and anxiety are common medical problems with significant impact on individual patients and society as a whole. The Global Burden of Disease Survey 2015 (GBD 2015) estimates that 1.5 billion people have significant headaches and 1 billion experience at least one migraine headache annually, making headache and migraine the second and third most prevalent diseases globally. Anxiety disorders are less prevalent but are estimated to affect roughly 250 million people, making anxiety one of the 30 most common disorders surveyed in GBD 2015.[1] This estimate for the prevalence of anxiety may be low: a meta-analysis of studies of anxiety prevalence estimated that 7.3% of the global population (approximately 500 million people) met the diagnostic criteria for anxiety

disorder.[2] Dizziness is not assessed by the GBD but a recent meta-analysis reports that lifetime prevalence of dizziness has been estimated to be between 17-30%.[3] Care for presentations of dizziness account for at least 4% of total emergency department costs in the United States, exceeding $4 billion dollars annually.[4]

Headache, dizziness, and anxiety are diagnosed primarily based on self-reporting of symptoms and history and have multiple etiologies: similar symptoms in different patients may have completely different causes. As a result, even the most effective treatments for headache, dizziness, and anxiety inadequately reduce symptoms for a substantial proportion of patients diagnosed with these conditions.[5-9]

Efforts to understand the etiology of headache, dizziness, and anxiety – and thus improve treatment for all three – have led to the discovery that there are significant comorbidities between each of these conditions, although the specific causes of the correlations have not been identified. Dizziness and anxiety are commonly comorbid.[10-12] Symptoms of migraine associated with dizziness are common enough to be recognized as a distinctive disorder, vestibular migraine.[13,14] Current theories regarding a mechanism that could cause symptoms of headache, anxiety, and dizziness have not been tested.[15] In addition, current proposals link dizziness and anxiety to mechanisms proposed to cause migraine, but people with non-migraine headache also report high levels of dizziness and anxiety.[16]

Vertical heterophoria (VH) is a form of binocular vision dysfunction (BVD) where the line of sight from one eye is vertically higher than the line of sight from the other eye when fusional vergence is disrupted, such as when using a Maddox Rod or prism.[17,18] VH has been shown to cause symptoms of headache, dizziness, and anxiety, as well as ambulation difficulties, neck pain, nausea and motion sickness.[18-22] Prevalence estimates of VH vary widely and range from 7%-52%, with best estimates at approximately 20% of the general population.[23,24] Although VH is common, patients with intractable headache, dizziness, and/or anxiety are rarely screened for VH as there is lack of awareness of this condition within the medical and vision communities.

This study builds on an earlier retrospective study of 38 TBI patients with long-term history of headache, dizziness, and anxiety which had not responded to treatment (average length of symptoms 9.9 years). The earlier study followed the same methods used in the current study and found that application of micro-prismatic lenses to treat the patient's VH led to an average subjective reduction of VH symptoms of 80.2%, as well as a statistically significant reduction in all metrics measuring their headache, dizziness, anxiety and BVD symptom burden.[25]

At least three factors that have prevented identification of VH as a potential cause of headache, dizziness, and anxiety symptoms:

1. Serious symptoms are regularly produced by heterophorias of 2D or below, which are below the levels that can be reliably detected by existing tests for vertical misalignment. In our 2016 study, 68% of participants were treated with vertical prism prescriptions between 0.5–2.00 diopters (mean=1.92D; median=1.5D). Studies measuring the test-retest reliability of current testing methods has measured 95% confidence intervals between 2D and 4D for various techniques.[26,27] Other studies have documented larger inconsistencies both for dissociated phoria and associated phoria tests.[22,28-30] Additionally, there is no consensus on how to interpret the amount of prism to prescribe based on test results. It is common practice to use anywhere from one third the amount to the full amount of prism indicated by the tests.[17,31] As would be expected, our recent study found that dissociated phoria tests did not consistently detect the small vertical misalignments of the participants. The success of tests ranged from 16.2% (Von Graefe phoria – near) to approximately 64% (for both Von Graefe phoria – far and vertical vergence testing).[25]
2. Most vertical heterophoria symptoms are not obviously visual in nature and therefore many patients are not screened for binocular vision dysfunction.[18,25] Patients who present with symptoms of headache, dizziness, and anxiety normally seek treatment from medical doctors who are not aware that these symptoms can be caused by vertical heterophoria and diagnose other conditions.
3. Screening instruments for VH generally examine only a subset of symptoms. For example, the Convergence Insufficiency Symptom Survey (CISS), a commonly used validated survey instrument, queries challenges with reading, headache, asthenopia, difficulty concentrating and visual fatigue. However, it does not query the other symptoms associated with VH such as problems with distance vision, dizziness, lightheadedness, nausea, motion sickness, neck pain, head tilt, anxiety, depth perception, or closing/covering an eye to make visual tasks

easier.[32,33] As a result, patients who do not exhibit the best-known symptoms of BVD will not be screened or diagnosed. Consistent with this expectation, most patients in the cohort examined in our recent study did not report a history of vision issues that would normally be indications of possible heterophoria: diplopia, shadowed/overlapping vision and closing/covering one eye to ease visual tasks was reported by only 39.5%, 34.2% and 34.2% of the patients respectively.[25]

Many highly symptomatic patients have heterophorias under 2.0 D, regularly as low as 0.5 D. Since existing screening and diagnostic tests are not precise enough to reliably identify heterophorias of these small magnitudes, a significant number of patients who have VH symptoms are not detected by these tests. Therefore, the authors developed a method that identifies small amounts of VH in symptomatic patients. This method, known as Prism Challenge, is based upon the standard optometric practice of determining prescriptions for corrective lenses by introducing incremental changes until the patient reports maximum visual clarity. The tester incrementally adds small units of prism (as low as 0.25D) to the subjective refraction until the patient reports maximum visual clarity and minimal symptoms. The patients are asked throughout the process to rate visual acuity and comfort while viewing a visual target. Patients then wear the trial frame for 15-20 minutes and are then again assessed for improvement. The diagnosis of BVD is established when patients report a marked reduction or elimination of BVD symptoms immediately after the application of prism. Although existing phoria tests were not always able to detect VH, we administered one or more tests to every patient to meet the current standard of care, comply with requests of referrers, and to collect data on the relative effectiveness of multiple methods. The primary evidence for the validity of Prism Challenge is the immediate reduction in symptoms of identified patients when treated for vertical heterophoria with prism.

The purpose of this paper is to examine the effectiveness of micro-prism lenses for reduction of headache, dizziness and anxiety in patients diagnosed with vertical heterophoria (VH).

Methods

This retrospective study was approved by Western IRB and adheres to the tenets of the Declaration of Helsinki. The study group included 111 patients who presented to an optometric binocular vision subspecialist between July 2009 and June 2011 for assessment of symptoms consistent with VH.

The study group was drawn from patients who were referred for assessment by specialists, case managers or self after their symptoms had not responded to other treatments. During the period examined in the study, approximately 1150 patients in total were diagnosed with VH after assessment with Prism Challenge and were given prescriptions for corrective lenses including vertical prism.

All patients were asked to complete all survey instruments before treatment and at the completion of their treatment (generally 8-12 weeks after initial appointment). Most of the patients who received treatment did not complete these instruments. Thus, complete data for this study was available for approximately 135 of the patients who were treated during the study period. One of the survey instruments used was a 10-cm visual analogue scale (VAS) with the question, "Compared to the way I felt before I came to Vision Specialists: If you are feeling better, by what percentage have you improved?" A small number of patients (less than 10) who marked a point below 3 cm on this answer at the completion of treatment were excluded from the study. Fifteen patients were excluded because they did not report symptoms of headache, dizziness, or anxiety with the survey instruments used in this study. This study examines the group of 111 patients who completed all survey instruments and whose initial scores on pre-intervention instruments indicate significant symptoms of headache, dizziness, and/or anxiety.

The examination phase consisted of a complete ocular and refractive exam coupled with a detailed binocular vision examination, which included multiple dissociated phoria tests. Patients were assessed with the Titmus test, Von Graefe phoria testing near and far, vertical vergence test and the Modified Thorington test using the Bernell Lantern positioned at 3 feet for vertical misalignment testing. Most participants (83.7%) were assessed with at least three of the five methods. The presence and direction of a head tilt was noted and documented.

VH diagnosis was established with Prism Challenge. Small units of vertical prism (usually 0.25D) are incrementally added to a trial frame containing the patient's subjective refraction. The direction of correction is assigned based on the results of the earlier VH tests and the patient's head posture/tilt. The patients are asked throughout the process to rate

visual acuity and comfort while viewing a visual target. The patient then wears the trial frame with prism in place for 15-20 minutes and is then again assessed for improvement. Prism Challenge is considered positive (and the initial vertical prism prescription is established) when the patient reports that the accumulated vertical prism prescription increased visual clarity while simultaneously minimizing BVD symptoms.

The treatment phase entailed the patient wearing the initial refractive and prism prescription (as determined by Prism Challenge) for 2-4 weeks. After this time, the patient returned for one or two follow-up appointments for prescriptive adjustments to address their remaining symptoms. The final follow-up visit took place on average 8-12 weeks after the initial intervention. Final data for this study was collected at that appointment.

Data collected prior to intervention included baseline demographics and a detailed review of systems (ROS). Data collected prior to and at the conclusion of prism intervention included a patient self-assessment of dizziness, anxiety and headache on a 0-10 scale, and results from three validated survey instruments: Headache Disability Inventory (HDI), Dizziness Handicap Inventory (DHI), and Zung Self-Rating Anxiety Scale (SAS). All three tools measure the impact of a condition on a patient's ability to function rather than an abstract measurement of symptoms.

The Headache Disability Inventory contains 25 items which can be answered "no/sometimes/yes", with scores of 0, 2, and 4 for answers that indicate increasingly severe symptoms, leading to a range between 0 and 100. The test has two components, emotional and functional. It has high reliability (Cronbach's alpha analysis r = 0.94). When comparing HDI scores with self-reported headache frequency and severity, the authors found that mean HDI scores for patients reporting mild headaches were 32.33, moderate headaches 33.72, and severe headaches 60.73. Based on the standard error of 10.06, the authors calculated that the 95% confidence interval of a measurable treatment effect would be shown by a 29-point reduction in HDI score. They acknowledged that this number created a significant "floor effect" since many subjects reporting mild or moderate headache pain scored less than 29 on the inventory.[34] The threshold of 20 was chosen to include a majority of patients with at least mild headache disability.

The Dizziness Handicap Inventory also contains 25 items and uses the same scoring format and range. The test has three components, functional, emotional, and physical. It has high reliability (Cronbach's alpha analysis r = 0.91). When comparing DHI scores with self-reported frequency of dizziness, the authors found that mean DHI scores for patients reporting occasional dizziness was 24.8, frequent dizziness 34.2, and continuous dizziness 49.1. However, the standard deviations of scores in each group ranged from 17.8 to 22.3. There were significant differences between the three groups (t=2.16, P = .03 between occasionally and frequently, t=2.54, P = .01 between frequently and continuously). Based on these results, we categorized patients with a score of 10-39 to have mild or moderate dizziness disability, and patients with a score of 40 or higher as having severe dizziness disability. The standard error of measurement was 6.23, so a 95% confidence interval of a measurable treatment effect requires an 18-point reduction in DHI score.[34]

The Zung Self-Rating Anxiety Scale (SAS) includes 20 questions which can be answered with "None or a little of the time," and "Some of the time," "Good part of the time," "Most or all of the time." These produce scores between 1 and 4 for a total score between 20 and 80. The test was validated by testing with a control group and patients with a variety of diagnoses, including anxiety disorder.[35] Later interpretations of the SAS report that a score of 20-35 indicates normal anxiety; 36-47 indicates moderate anxiety, 48-59 indicates marked to severe anxiety, and 60+ severe anxiety.[36] The SAS has high reliability (Cronbach's alpha analysis r = .81). While a standard error for the SAS has not been published, the accepted range between different levels of symptoms is 12 points, and we used this number as the threshold for a significant reduction in symptoms.

Before and after treatment, data was also collected from a subjective rating (0-10 scale) of headache, dizziness and anxiety severity. Upon conclusion of treatment, subjective assessment of overall reduction of BVD symptom burden was obtained utilizing a 10-cm visual analogue scale (VAS) asking the question, "Compared to the way I felt before I came to Vision Specialists: If you are feeling better, by what percentage have you improved?" The final cumulative prism prescription was recorded.

Statistical Analyses

Initial analyses assessed the distributional properties of the study variables pre- and post-treatment. The distributions of differences scores between pre- and post-treatment were symmetric with a single peak, indicating that the assumption of normality of the mean difference scores was tenable. To assess

the efficacy of micro-prism lenses for reduction of headache, dizziness and anxiety changes pre- and post-treatment, matched pairs t-tests were performed. Results reporting mean and standard deviations of pre- and post-treatment scores, 95% confidence intervals of changes in scores pre- to post-treatment and p values for differences are provided. Cohen's d, calculated as the difference in mean pre-and post-treatment divided by the pooled standard deviation, is also provided as an effect size indicator for the treatment effect. Significance was set at $p \leq 0.05$. All analyses were completed using SPSS version 22.

Results

In this study, 25 participants (22.5%) were male and 86 (77.5%) were female. The average age was 39.9 years old, with a range of 6 to 80 years old. Average duration of symptoms was 8.1 years (range 1 month to 58 years). Prior to intervention, corrective eyewear (glasses and/or contact lenses) were worn by 80 (72.1%). Eye surgeries were reported by 15 patients (13.5%), three of whom reported surgeries for strabismus. Brain CT scans had been performed for 54 (48.6%), brain MRI had been performed for 58 (52.3%) and both tests had been performed for 39 (35.1%). Past medical history of headache, dizziness or anxiety was reported by 91.9%. Consultation with an ophthalmologist or optometrist occurred prior to study participation in 54.1% of the cases. Presenting complaint, frequency of consultations with specific types of providers prior to binocular vision assessment and prevalence of confounding diagnoses are listed in Figures 1-3.

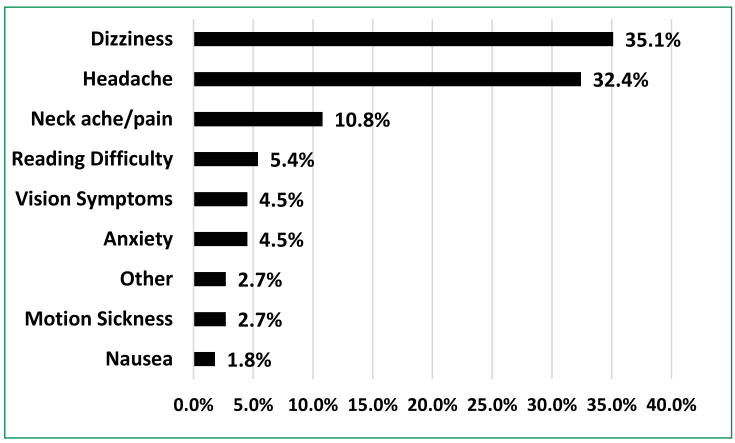


Figure 1. *Presenting Symptom (% of patients)*

Symptom Prevalence

An extensive ROS was performed and included 84 yes/no questions concerning vestibular symptoms, traditional heterophoria symptoms, reading difficulty,

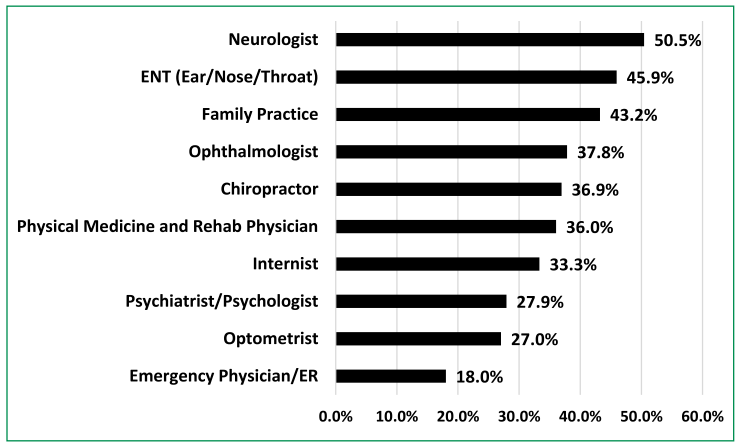


Figure 2. *Specialists Seen Prior To VH Diagnosis (% of patients).*

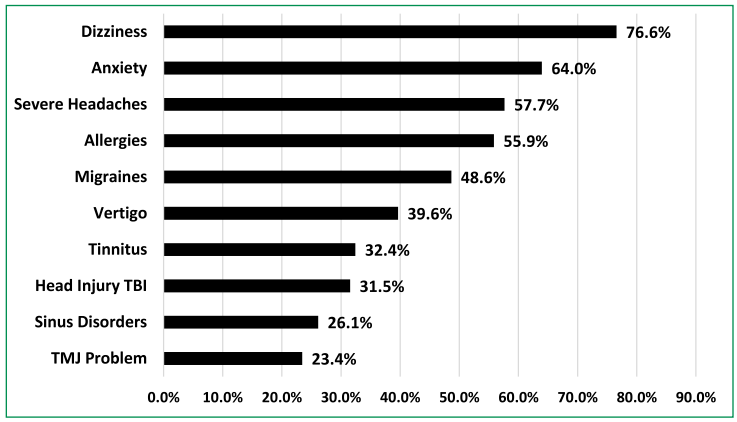


Figure 3. *Most Common Diagnoses Given Prior To VH Diagnosis (% of patients)*

pain, standard vision symptoms, and anxiety symptoms (Table 1). A chart showing the percentage of patients who answered affirmatively to the most pertinent BVD questions in the ROS is included (Figure 4). Headache (78.4%), neck ache (84.7%) and dizziness (76.6%) were reported more frequently than any of the heterophoria or reading symptoms (23.4-72.1%) except for fatigue with reading (76.6%). Diplopia, shadowed/overlapping vision and closing/covering an eye to ease visual tasks were experienced by 23.4%, 30.6% and 24.3% respectively. In the optometric examination, four patients were found to have horizontal heterophoria requiring horizontal prism of 2.0D or greater. Horizontal and vertical prism were both incorporated into the prescription of these patients.

Baseline assessment for headache, dizziness, and anxiety with the HDI, DHI, and SAS showed high prevalence of mild/moderate or severe disability. In total, 85.5% reported mild/moderate or severe disability from dizziness, 66.6% reported mild/moderate or severe disability from headache, and 72.9% reported mild/moderate or severe disability from anxiety (Figure 5). There was considerable overlap between the symptom reports: 46.8% reported symptoms on

Table 1. Symptoms Queried in Review of Systems

Visual Symptoms	Headache/Vestibular/Anxiety Symptoms	Past Medical History
Itchiness	Upper back or shoulder tension	General Fatigue
Spots/Floaters	Neck Ache	Cervical Spine Injury
Dryness	Head tilt	Kidney Disease
Gritty feeling in eyes	Facial pain	High Blood Pressure
Watery eyes	Sinus pain/pressure	Heart Disease
Burning eyes	Headaches	Skin Disorders
Eye strain	Nausea	Asthma
Sore eyes	Dizziness	HIV
Fatigue w reading	Lightheadedness	Thyroid Disorder
Trouble reading	Motion Sickness	TMJ Problem
Difficulty w reading comprehension	Drifting to one side while walking	Head Injury TBI
Losing your place while reading	Unsteadiness w walking	Migraines
Words run together w reading	Ear fullness Right or Left	Severe Headaches
Skipping lines while reading	Feeling uncoordinated	Sinus Disorders
Closing or covering one eye while reading	Vertigo	Meniere's
Trouble learning at work school or other activity	Lightheadedness with close up activities	Tinnitus
Trouble concentrating	Lightheadedness with distance activities	BPPV
Trouble adjusting to prior pair of glasses	Anxiety associated with dizziness	Sleep Apnea
Sudden loss of vision	Feeling overwhelmed or anxious in crowds	ADD ADHD
Flashes of light	Feeling overwhelmed in large spaces	Frequent urination
Tearing	Heart palpitations	Shortness of breath
Redness	Anxiety	Skin Rashes
Blurry near vision	Agoraphobia	Fainting
Trouble working up close		
Blurry distance vision		
Trouble seeing at night		
Double vision		
Shadowed overlapping vision		
Sensitivity to light		
Problems w reflection/glare		
Eye pain		
Pain with movement of eyes		
Poor depth perception		
Lazy Eye		
Cataracts		
Glaucoma		

all three assessments. Mild/moderate or severe anxiety alone was reported by 2.7%, anxiety with dizziness was reported by 18.0% and anxiety with headache was reported by 5.4% (Figure 6).

Pre Treatment Metrics

Most patients were given one or more standard tests for vertical heterophoria. Standard tests do identify larger heterophorias and were judged to be diagnostically helpful in some cases. In other instances, these tests were given at the request of referrers. Because the majority of participants had heterophorias of 2.0D or below, standard vertical alignment tests were not consistently able to identify the heterophorias in this population. Tests given predicted the presence and direction of the misalignment between 25.7%-57.6% of the time, while the observed direction of the head tilt predicted the presence and direction of the misalignment 74.3% of the time (Figure 7).

Pre and Post Treatment Metrics

The survey instruments all showed significant effects from treatment. The validated survey instruments indicated standard effect sizes of d = .54 for headache, d = .72 for dizziness, and d = .80 for anxiety following treatment ($p < 0.001$ for all three). Pre- and post-treatment measurements on these scales indicate significant reductions in the mean score for each group. For headache, the mean score on the HDI

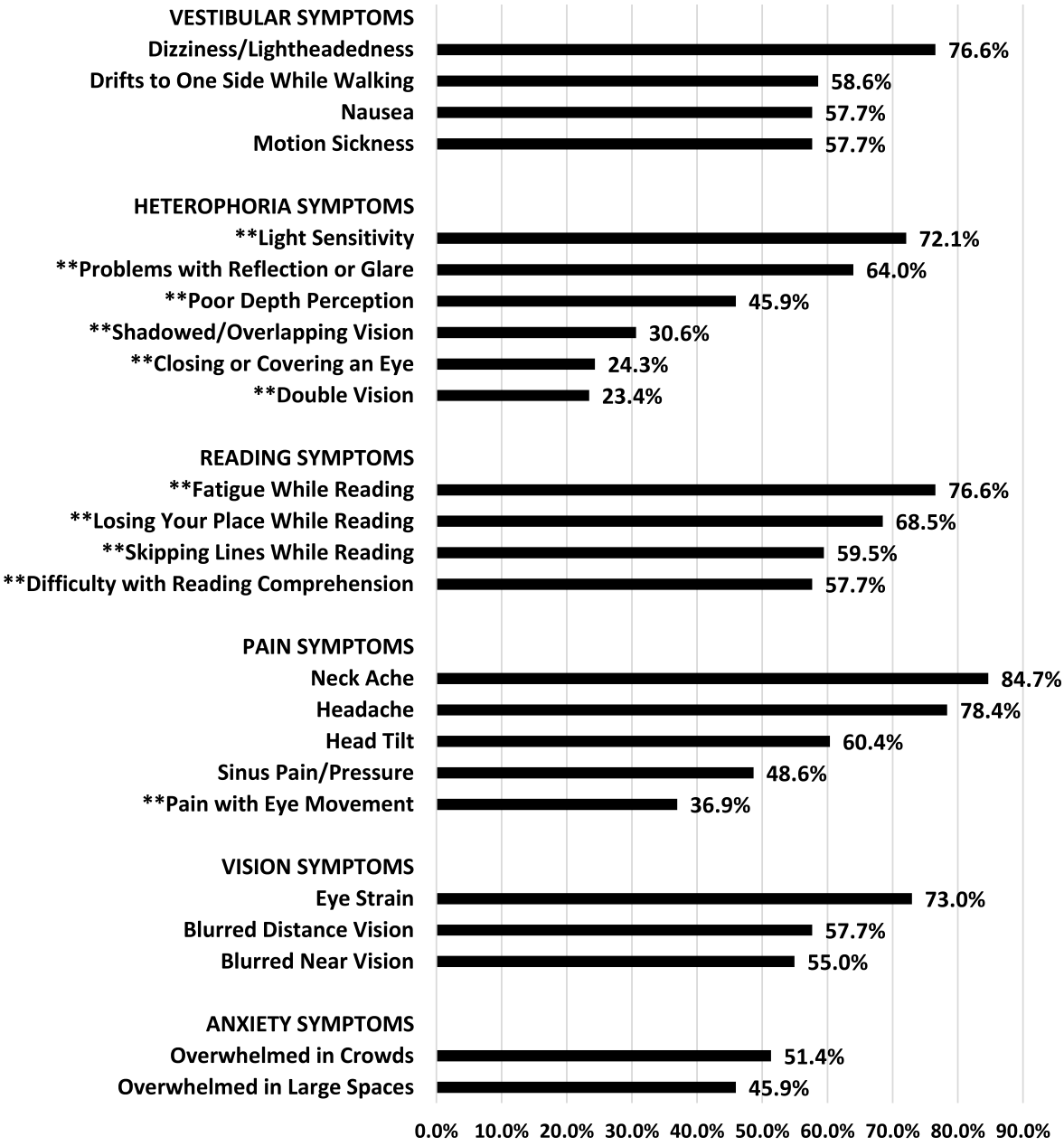


Figure 4. *Prevalence of Vertical Heterophoria Symptoms (% of patients) in 111 Patients (**indicates traditional vertical heterophoria symptoms)*

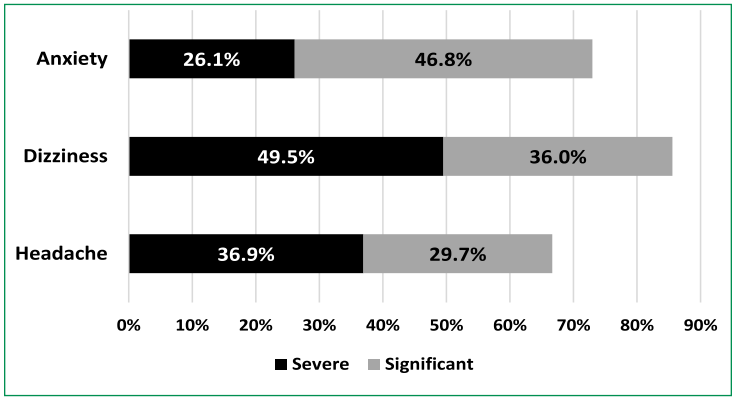


Figure 5. *Patients Reporting Severe or Significant Symptoms*

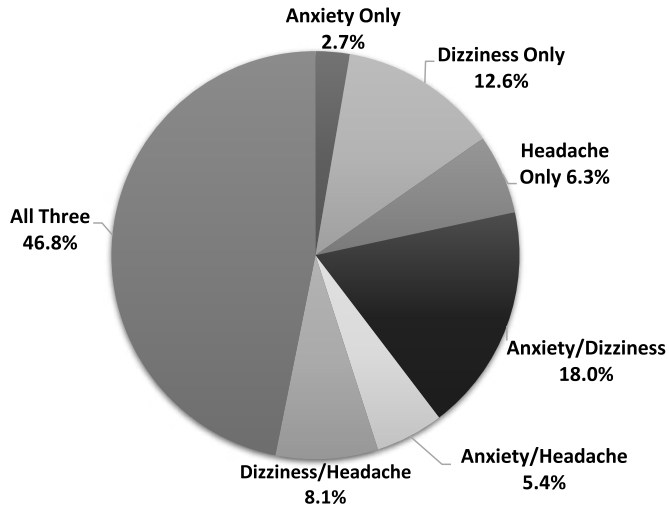


Figure 6. *Symptoms Reported by Patients on One or More of SAS, HDI, and DHI. (SAS≥36, HDI≥20, DHI≥10)*

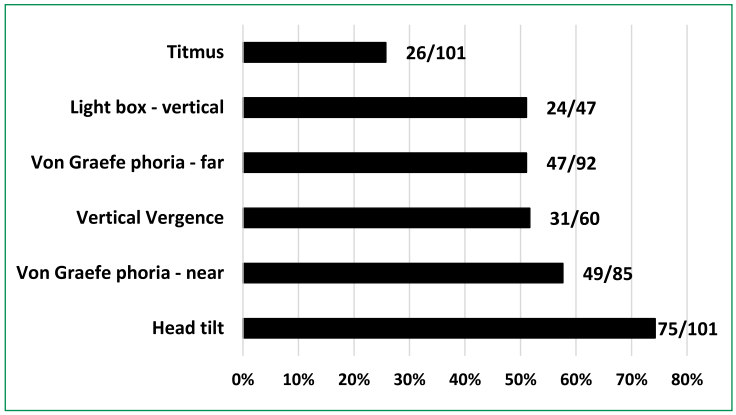


Figure 7. *Vertical Alignment Testing During Initial Evaluation (# correct tests / # of patients tested)*

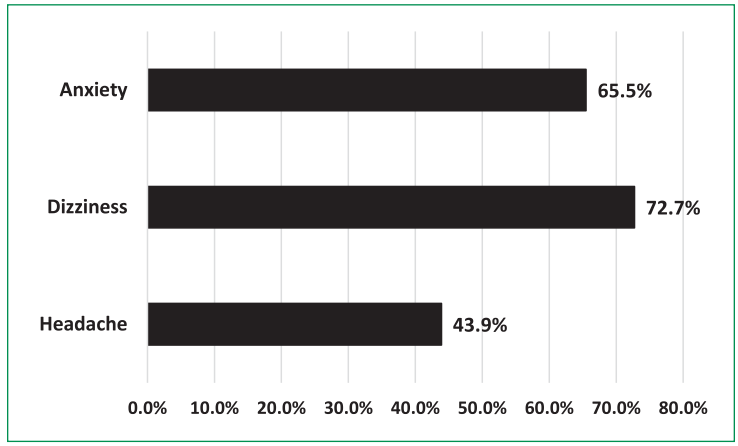


Figure 8. *Percentage of Severely Symptomatic Patients Reporting Improvement*

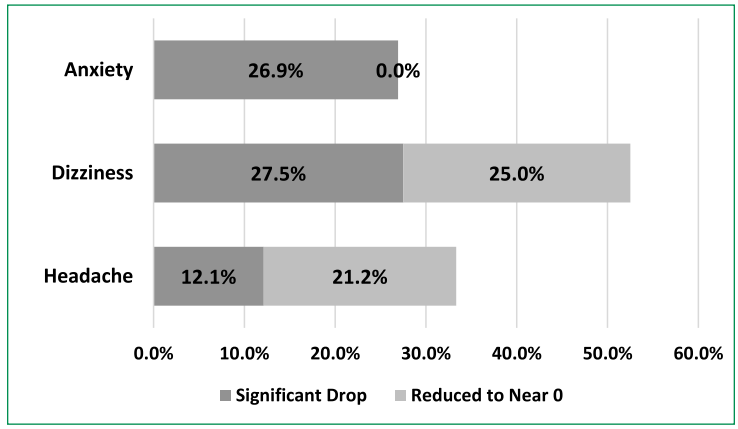


Figure 9. *Percentage of Significantly Symptomatic Patients Reporting Significant Improvement*

was reduced from 37.55 (95% CI:31.80—43.30) to 22.13 (95% CI: 17.24—27.02). For dizziness, the mean score on the DHI was reduced from 38.01 (95% CI: 32.99—43.05) to 18.68 (95% CI: 14.65—22.71). For anxiety, the mean score on the Zung SAS was reduced from 42.13 (95% CI: 40.12—44.16) to 34.22 (95% CI: 32.52—35.92).

The 1-10 rating scale produced effect sizes of d = 1.04 for headache, d = 1.03 for dizziness, and d = .72 for anxiety ($p < 0.001$ for all three). When asked to report their symptom improvement on a VAS, the average mark of improvement was 7.77 cm on the 10-cm line (95% CI=7.51-8.03).

Subgroup analysis of the DHI, HDI and SAS also demonstrated significant improvement. For dizziness, 40 of 55 (72.7%) patients initially reporting severe disability (> 40) due to dizziness had statistically significant reductions of 18 or greater in their post-treatment DHI score. For the 40 patients reporting mild or moderate disability (10-39), 11 reported reductions of 18 or greater on the DHI score. An additional 10 reported initial scores of less than 18 and final scores of 4 or less. Combining these groups, 21 of 40 (52.3%) of mildly or moderately disabled patients reported significant improvement or near-total elimination of symptoms. For headache, 18 of 41 (43.9%) patients initially reporting severe disability (> 45) due to headache had statistically significant reductions of 29 or greater in their post-treatment HDI score. For the 33 patients reporting mild or moderate disability (20-44), 4 reported reductions of 29 or greater on the HDI. An additional 7 reported initial scores of less than 30 and final scores of 10 or less. Thus, 11 of 33 (33.3%) of moderately disabled patients reported significant improvement or near-total elimination of headache disability. For anxiety, 19 of 29 (65.5%) patients initially reporting severe anxiety (>48) had significant reductions of 12 or greater in their post-treatment SAS score. For the 52 patients reporting mild or moderate anxiety (36-47), significant reductions of 12 or greater in their post-treatment score occurred in 14 (26.9%). These results are shown in Figures 8 and 9.

Post Treatment Metrics

Total vertical prism prescription between 0.50 and 2.00 diopters was noted for 75.7% of the participants, between 2.25 and 4.00 diopters for 22.5%, and greater than 4.00 diopters for 1.8% (two participants). Base in horizontal prism prescription of 0.50 was prescribed for 67.6% of participants, 1.0 diopters for 9.0%, 1.5-2.0 diopters for 4.5%, 2.5-4.0 diopters for 3.6%, and 5.0 or greater for 1.8%. Base out horizontal prism was included for 3.6% of patients. Initial measurements of symptoms on the HDI, DHI, and SAS did not correlate with the amount of vertical prism prescribed. The average duration of treatment was 10.7 weeks (range 2.0-48.3 weeks).

Discussion

Identification of VH (a form of BVD) in this patient cohort and treatment of the misalignment with micro-prism lenses led to a marked reduction in all

metrics for symptoms of headache, dizziness and anxiety, as well as for subjective metrics for overall symptom reduction.

The average 10.7-week duration of treatment is consistent with our overall clinical experience of 8-12 weeks. During this time, the clinician typically makes 1-3 changes in the lens prescription based on patient reports of changes to their symptoms. While improvements continue to take place over a period of weeks, patients experience almost immediate improvement: every patient considered in this study reported improvements within 20 minutes of the introduction of a corrective lens with vertical prism.

This study demonstrates the ability of the Prism Challenge technique to diagnose and initiate treatment of VH/BVD in patients with headache, dizziness, and anxiety, and to make changes to the treatment to improve outcome. Utilizing this approach, over 10,000 patients with BVD have been diagnosed, treated, and observed over the last 23 years. This has clarified the set of BVD symptoms, many of which are not usually associated with BVD. This approach holds great promise not just for identifying and treating patients but also for further studying BVD and BVD-associated symptoms.

Symptoms traditionally associated with BVD--diplopia, shadowed/overlapping vision and closing/covering an eye to ease visual tasks - were individually experienced by only approximately 25% of this cohort (Figure 4). While 54.1% of the patients had been evaluated by an ophthalmologist, optometrist or both, none had been previously diagnosed with VH. These patients may not be getting diagnosed because they do not report traditional visual symptoms of BVD and are thus not tested, and also because the phoria tests lack adequate sensitivity to reliably identify the presence and direction of vertical misalignment in this patient cohort.[26,27,28,29] Prism Challenge is based on the same principle generally used to determine prescriptions for corrective lenses: patients are given lenses with incremental changes, and a prescription is elucidated based upon the patient's report of minimized symptoms. This has been a much more reliable method of identifying the prism needed to treat the vertical heterophoria and reduce the associated symptoms. It should be noted that the presence of and direction of a head tilt observed during physical examination was the most reliable indicator of the presence and direction of vertical misalignment (Figure 7).

The patients in this cohort had either a very small amount or small amount of vertical misalignment (75.7% having accumulative vertical prism prescription between 0.5 and 2.0D, and 22.5% between 2.5 and 4.0D) yet were quite symptomatic (baseline average HDI=37.5; DHI=38.0; Zung=42.1) and improved significantly with micro-prism lenses. This emphasizes the need to be able to identify and treat heterophorias requiring very small amounts of prism, as they can precipitate significant morbidity.[30]

Males comprised a minority of this patient cohort at 22.5%, which was reflective of the overall population of patients who were assessed during this period. This gender imbalance in symptom reports might be explained by the fact that the most prevalent presenting complaints in this group were dizziness (35.1%) and headache (32.4%) (Figure 1), which are much more common in females than males.

It has been previously hypothesized that, given the coexistence of headaches, dizziness and anxiety symptoms in many patients, there should exist a common cause, with a single common treatment.[15] To the author's knowledge, BVD, of which VH is a subset, appears to be the only entity identified that is causative of all three symptoms, and where treatment positively impacts all three symptoms.

Since evaluating for VH is non-invasive, patients experiencing headache, dizziness, and/or anxiety should be assessed for VH, ideally before prescribing medication or recommending invasive treatments for these symptoms. In particular, patients with a combination of these symptoms, and those who have not responded to other treatments warrant an evaluation for VH.

Study Limitations

This is a retrospective study, and as such, has the potential to introduce certain biases into the data and into the interpretation of that data. The most serious potential bias is the use of patient improvement as a diagnostic tool. While this bias was inherent in the selection, the number of patients excluded on this basis (less than 10) is not high enough to invalidate the study results.

Given that this line of inquiry is new, we are currently the only center reporting data on this at this time. However, we have begun the process of training other vision care providers in our techniques, and it is anticipated that multi-center trials will be performed in the future.

Patients eligible for this study were diagnosed with a report of positive response to prism lenses within 20 minutes of application. It is standard practice in optometry to determine a diagnosis and prescription for corrective lenses by making incremental changes

to the prescription until the patient reports minimal symptoms of visual distortion. Ideally the accuracy of Prism Challenge would be verified by comparison to other phoria tests. However, the most precise phoria tests in common use have error of 2.0D. A more precise phoria test would greatly simplify the process of identifying and treating this patient cohort.

The SAS, DHI, and HDI have different scales, and comparative results may reflect differences between the tests. In particular, the lower number of patients reporting statistically significant improvement in headache symptoms may be the result of a high standard error reported on the HDI. We are working on the creation of a validated instrument that will enable a more accurate comparative assessment of symptoms in these and other symptom areas of VH.

Not every patient had every vertical alignment test performed during the initial evaluation, as it was at the discretion of the optometrist as to which test or tests to utilize. While this inconsistent testing strategy could have introduced bias, the large number of patients that were tested with each of the individual tests and the concomitant results (all demonstrating less than adequate sensitivity) makes that less likely.

Only dissociated phoria tests were performed with this patient population, as our previous experience with associated phoria tests found them lacking. An additional study that compared Prism Challenge with both dissociated and associated phoria tests for identifying vertical misalignment would provide a more thorough understanding of the utility (or lack thereof) of these tests in this population.

Since there was no sham control and since patients were not blinded to their treatment with prismatic lenses, it is possible that a placebo effect had an impact on the results. However, this is less likely since the effects of prismatic lenses are not subtle. When prismatic lenses are worn by those who require them, noticeable relief of symptoms is obtained. Conversely, when these lenses are worn by those who do not require them, symptoms of VH develop, most notably nausea, anxiety/dysphoria, and dizziness.

The societal prevalence of VH using this new approach could not be determined from this retrospective study. Additional studies will be required to obtain this important datum.

Conclusions

Treatment with micro-prism lenses (the amount and direction determined by using the Prism Challenge technique) markedly reduces symptoms of headache, dizziness, and anxiety in patients diagnosed with vertical heterophoria. The effectiveness of this treatment approach highlights the need for further prospective and multi-center studies as well as the need for deeper mechanistic understanding of the pathophysiology of VH. The need for further study notwithstanding, the minimal risks and cost effectiveness of this therapeutic approach should make screening for and treating VH a consideration for patients with headache, dizziness, and anxiety. This would be particularly true for those patients who have experienced less than desirable outcomes with standard treatment modalities.

Acknowledgements

James Janisse assisted in statistical analysis. Alan Terlep edited and provided additional statistical analysis.

Dr. Debby Feinberg and Dr. Mark Rosner have a proprietary interest in Vision Specialists of Michigan.

References

1. Vos T, Allen C, Arora M, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: A systematic analysis for the Global Burden of Disease Study 2015. Lancet , 2016; 388(10053):1545-1602.
2. Baxter AJ, Scott KM, Vos T, Whiteford HA. Global prevalence of anxiety disorders: A systematic review and meta-regression. Psychol Med 2013;43:897-910.
3. Murdin L, Schilder AGM. Epidemiology of balance symptoms and disorders in the community: A systematic review. Otol Neurotol 2015; 36: 387–92.
4. Saber Tehrani AS, Coughlan D, Hsieh YH, et al. Rising annual costs of dizziness presentations to US emergency departments. Acad Emerg Med 2013;20:689-96.
5. Staab JP, Ruckenstein MJ. Expanding the differential diagnosis of chronic dizziness. Arch Otolaryngol Head Neck Surg 2007;133:170-6.
6. Newman, MG, Llera SJ, Erickson TM, et al. Worry and generalized anxiety disorder: A review and theoretical synthesis of evidence on nature, etiology, mechanisms, and Treatment. Annu Rev Clin Psychol 2013;9:275-97.
7. Hainer BL, Matheson EM. Approach to acute headache in adults. Am Fam Phys 2013;87(10):682-7.
8. Campbell-Sills L, Roy-Byrne PP, Craske MG. Improving outcomes for patients With medication-resistant anxiety: Effects of collaborative care with cognitive behavioral therapy. Focus 2017;15:211-8.
9. Irimia PI, Palma JA, Fernandez-Torron R, Martinez-Vila E. Refractory migraine in a headache clinic population. BMC Neurol 2011;1:11:94.
10. Zur O, Schoen G, Dickstein R, et al. Anxiety among individuals with visual vertigo and vestibulopathy. Disabil Rehabil 2015; 37: 2197-202.

11. Lahmann C, Henningsen P, Brandt T, et al. Psychiatric comorbidity and psychosocial impairment among patients with vertigo and dizziness. J Neurol Neurosurg Psychiatry 2015;86:302-8.
12. Staab JP, Ruckenstein MJ. Which comes first? psychogenic dizziness versus otogenic anxiety. Laryngoscope 2003;113:1714–8.
13. Furman, JM, Marcus, DA, Balaban, CD. Vestibular migraine: Clinical aspects and pathophysiology. Lancet Neurol 2013;12:706-15.
14. Stolte B, Holle D, Naegal S, et al. Vestibular migraine. Cephalalgia 2015;35:262-270.
15. Furman JM, Balaban CD, Jacob RG, Marcus DA. Migraine–anxiety related dizziness (MARD): a new disorder?. J Neurol Neurosurg Psychiatry 2005;76:1-8.
16. Saunders K, Merikangas K, Low NCP, Von Korff M, Kessler RC. Impact of comorbidity on headache-related disability. Neurology 2008;70(7):538-547.
17. Borish IM. Versions and Vergences. In: Clinical Refraction. 3rd ed. Chicago, IL: The Professional Press, Inc., 1975: 189-256.
18. Duke-Elder S, Wybar K. Anomalies of Binocular Fixation. In: System of Opthamology. St. Louis, MO: The C. V. Mosby Company, 1973: 513-76.
19. Bixenman WW. Vertical prisms. Why avoid them? Surv Ophthalmol 1984;29:70-8.
20. Roy RR. Symptomatology of binocular stress. Optom Wkly 1958;49:907-12.
21. Schrier M. Practice notes on hyperphoria. British J Optom Dispensing 1997;5:68-9.
22. Borish IM. Analysis and Prescription. In: Clinical Refraction. 3rd ed. Chicago, IL: The Professional Press, Inc., 1975: 861-938.
23. Jackson DN, Bedell HE. Vertical heterophoria and susceptibility to visually induced motion sickness. Strabismus 2012;20:17-23.
24. Surdacki M, Wick B. Diagnostic occlusion and clinical management of latent hyperphoria. Optom Vis Sci 1991;68:261-9.
25. Rosner MS, Feinberg DL, Doble JE, Rosner AJ. Treatment of vertical heterophoria ameliorates persistent post-concussive symptoms: A retrospective analysis utilizing a multi-faceted assessment battery. Brain Inj 2016;30(3):311-7.
26. Gray LS. The prescribing of prisms in clinical practice. Graefes Arch Clin Exp Ophthalmol 2008;246:627-9.
27. Schroeder TL, Rainey BB, Goss DA, Grosvenor TP. Reliability of and comparisons among methods of measuring dissociated phoria. Optom Vis Sci 1996;73:389-97.
28. Gall R, Wick B. The symptomatic patient with normal phorias at distance and near: What tests detect a binocular vision problem? Optometry 2003;74:309-22.
29. Karania R, Evans BJ. The Mallett fixation disparity test: Influence of test instructions and relationship with symptoms. Opthalmic Physiol Opt 2006;26:507-22.
30. Doble JE, Feinberg DL, Rosner MS, Rosner AJ. Identification of binocular vision dysfunction (vertical heterophoria) in traumatic brain injury patients and effects of individualized prismatic spectacle lenses in the treatment of postconcussive symptoms: A retrospective analysis. Phys Med Rehab 2010;2:244-53.
31. Wick BB. Prescribing vertical prism: How low can you go? J Optom Vis Devel 1997;28:77-85.
32. Borsting EJ, Rouse MW, Mitchell GL, et al. Validity and reliability of the revised convergence insufficiency symptom survey in children aged 9 to 18 years. Optom Vis Sci 2003;80:832-8.
33. Rouse MW, Borsting EJ, Mitchell GL, et al. Validity and reliability of the revised convergence insufficiency symptom survey in adults. Ophthalmic Physiol Opt 2004;24:384-90.
34. Jacobson GP, Newman CW. The development the dizziness handicap inventory. Arch Otolaryngology–Head & Neck Surgery 1990 Apr 1;116(4):424-7.
35. Zung, WWK. A rating instrument for anxiety disorders. Psychosomatics 1971;12: 371-9.
36. Jegede, RO. Psychometric attributes of the self-rating anxiety scale Psychological Reports 1977;40: 303-6.

Correspondence regarding this article should be emailed to Mark Rosner, MD, at DrMark@nvminstitute.org.

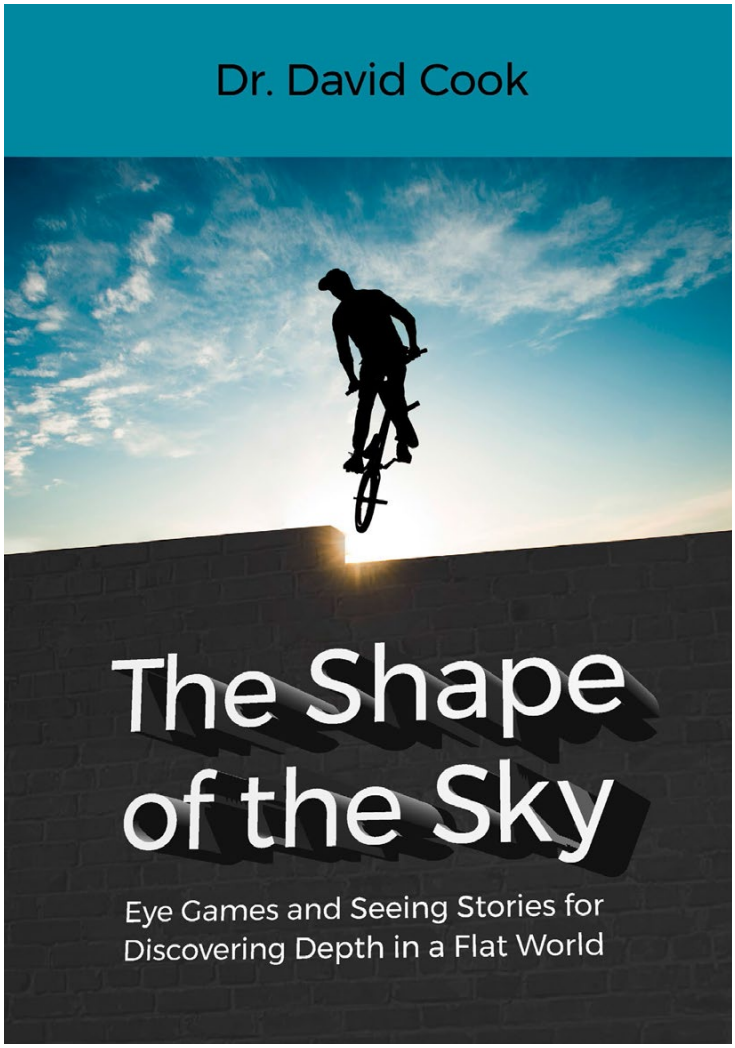
Feinberg DL, Rosner MS, Rosner AJ. Vertical heterophoria treatment ameliorates headache, dizziness and anxiety. Optom Vis Perf 2019;8(1):24-34.

OPTOMETRIC EXTENSION PROGRAM FOUNDATION

Your enrollment in OEPF goes beyond the tangible benefits you receive directly. It makes you part of a "family" of thousands of Clinical Associates worldwide who continue to advance human progress through research and education on vision, the visual process, and optometric clinical care. We work tirelessly to connect you with these colleagues, provide one of a kind continuing education experiences, facilitate access to research within the profession, and overall support your unique profession! The OEP Foundation has been providing these benefits for 90 years!

The information provided in the link below outlines many of the tangible benefits that you will receive from your investment – the unique quarterly publications, the discounted registration at all our education offerings, your practice information listed on our global "Find an Optometrist" page, and more!

To enroll www.oepf.org/clinical-associates



Get yours today!
https://www.oepf.org/product/shape-sky

Our first new book of 2020!
Join author **David Cook**, who for forty years has taught patients to experience the dimensions of space. Dr. Cook's lectures have delighted audiences around the globe. Now he shares his expertise with doctors, therapists, and anyone who has a curiosity about how we see the world.

Vision is not something that happens to us, Cook explains, but rather something we have learned to do. We see what we value. Routine eye exams value how little we can see; this book values how big we can see, the heights of perception rather than just the bottom of the eye chart.

We imagine that those standing beside us share our view of the world. Learn how nothing could be further from the truth. How we do vision is the difference between excelling in the flat, close world of books or navigating the depths of winding, crowded roads in the dark of night.

Having read this book, doctor and patient alike will see the world in a new way, a way that truly captures the shape of the sky.

Watch the interview!