Article ▸
Reduction of Magnitude and Frequency of Vertical Strabismus through Vision Therapy

Emily Aslakson, OD, Michigan College of Optometry, Big Rapids, Michigan

ABSTRACT

Background: Vertical strabismus tends to be a condition that many optometrists treat with spectacle prism only. They may even offer surgical correction, rather than attempting vision therapy. Even optometrists who are fairly comfortable with vision therapy may shy away from offering therapy to patients with this condition because they believe that it is too time intensive or just does not work. Oftentimes, this means that patients are unaware of the option of vision therapy, even though they may be motived and willing to undergo this treatment.

Case Report: This case outlines a 21-year-old Caucasian female with an 18^{Δ} high-frequency intermittent left hypertropia who underwent office-based therapy and had exceptional results, in the reduction of both the magnitude and the frequency of her vertical deviation.

Conclusion: Office-based vision therapy is a viable and effective treatment method for patients with vertical strabismus. Patient motivation is critical to the effectiveness of the treatment. This case demonstrates the efficacy of intensive office-based vision therapy on a patient with vertical strabismus.

Keywords: hypertropia, prism, vergence, vertical strabismus, vision therapy

Introduction

It is estimated that roughly 20% of the population has some type of vertical deviation.[1] There is a wide range of symptoms of vertical deviation, as described below:[1-3]

- generalized asthenopia
- symptoms mimicking ocular surface disease
- neurological symptoms such as headache, dizziness, and motion sickness
- musculoskeletal symptoms manifesting as neck, shoulder, or back pain due to unusual head turns and tilts

Many of these patients, such as the patient described in this case study, also have cosmetic complaints with their spectacle correction. Their glasses are often very thick and heavy, and depending on the magnitude of the prismatic correction, their ocular misalignment can appear worse to outside observers.

Prismatic spectacle correction is the most common treatment for these patients. The prescribed prism can be neutralizing, relieving, or fusional prism. Neutralizing prism refers to prescribing the full magnitude of the deviation as measured by cover test. Relieving prism is the minimum amount of prism needed to alleviate diplopia subjectively. Fusional prism is the minimum amount of prism required by the patient to fuse, as measured by their associated phoria. It is important to note that both relieving prism and fusional prism provide a source of passive vision therapy, as the patient is still actively working to maintain fusion and comfortable single vision.

There are several case reports in the literature describing patients with vertical deviations who underwent vision therapy.[4-6] These cases all follow a common method, including initially prescribing the minimum amount of fusional prism required by the patient, then undergoing office-based vision therapy with an emphasis on increasing horizontal fusional ranges. Prism is decreased at intervals throughout therapy, with the goal of completely removing prismatic correction from the patient's spectacles. With each decrease in prismatic correction, vision therapy continues to address horizontal fusional ranges. At the end stages of therapy, stress prism (vertical prism in the opposite direction of what is needed by the patient) is used to work vertical fusional ranges actively.

Case History

AC, a 21-year-old Caucasian female, presented to our clinic with the complaint of longstanding, oblique diplopia due to a congenital left superior oblique palsy. She had been aware of this condition since childhood and had 7^{Δ} of vertical prismatic correction in her spectacles at that time. She was interested in beginning vision therapy to help relieve her constant diplopia, which she experienced even with prismatic correction. She reported that her diplopia was always worse at near, worse at the end of the day, and worse in right gaze. Of specific concern, she noted difficulty with brushing her teeth and reported that she had to adopt unusual and uncomfortable head and body positions to get the toothpaste on her toothbrush each day. Upon observation, the patient presented with an adaptive head turn to her right and a slight head tilt down and to her right. Her ultimate goals were to reduce or perhaps to eliminate the prism in her glasses, as her glasses were quite heavy. She also wanted to wear contact lenses, which she had always been told were not an option for her. Her medical history was unremarkable, and she reported no medications and no known drug allergies. Table 1 lists pertinent initial examination data.

Table 1. Pertinent Examination Findings Prior to Vision Therapy

Best corrected distance and near acuities	20/20 OD, OS
Pupils	PERRLA, (-) APD
Confrontation visual fields	FTFC OD, OS
Extraocular muscles	Restricted up gaze, full ductions OD, OS
Habitual correction	OD: +3.75-2.75 x 177 3.5$^{\Delta}$ BU (20/20) OS: +3.50-1.75 x 175 3.5$^{\Delta}$ BD (20/20-2)
Cover test (c̄ habitual Rx)* *Tropia was very high frequency, D/N	D: 10$^{\Delta}$ ILET, 12-13$^{\Delta}$ ILHT Near: 6$^{\Delta}$ ILET, 12$^{\Delta}$ ILHT
Dry subjective refraction	OD: +4.00-2.25 x 175 3.5$^{\Delta}$ BU (20/20) OS: +4.00-2.00 x 173 3.5$^{\Delta}$ BD (20/20)
NPC (cm)	10/12
Stereopsis	40" of arc, +Randot
Horizontal vergences (near; c̄ habitual Rx)	BI: x/12/8; BO: x/20/15
Vertical vergences (near; c̄ habitual Rx)	OD Supra 5/4; Infra 10/6
Parks 3 step	LSO palsy
Hess-Lancaster	LSO underaction; RSR underaction
Worth 4 dot (bright illumination; c̄ habitual Rx)	Nose to 10': fusion 10-13': alternating suppression/fusion 13'+: diplopia or OS suppression
Fixation disparity (thru habitual correction)	7$^{\Delta}$ BD OS
Accommodative amplitudes (push-up)	7.5 D OD, OS
Anterior segment	Unremarkable
Intraocular pressure	12 mm Hg OD, 12 mm Hg OS
Posterior segment	Unremarkable

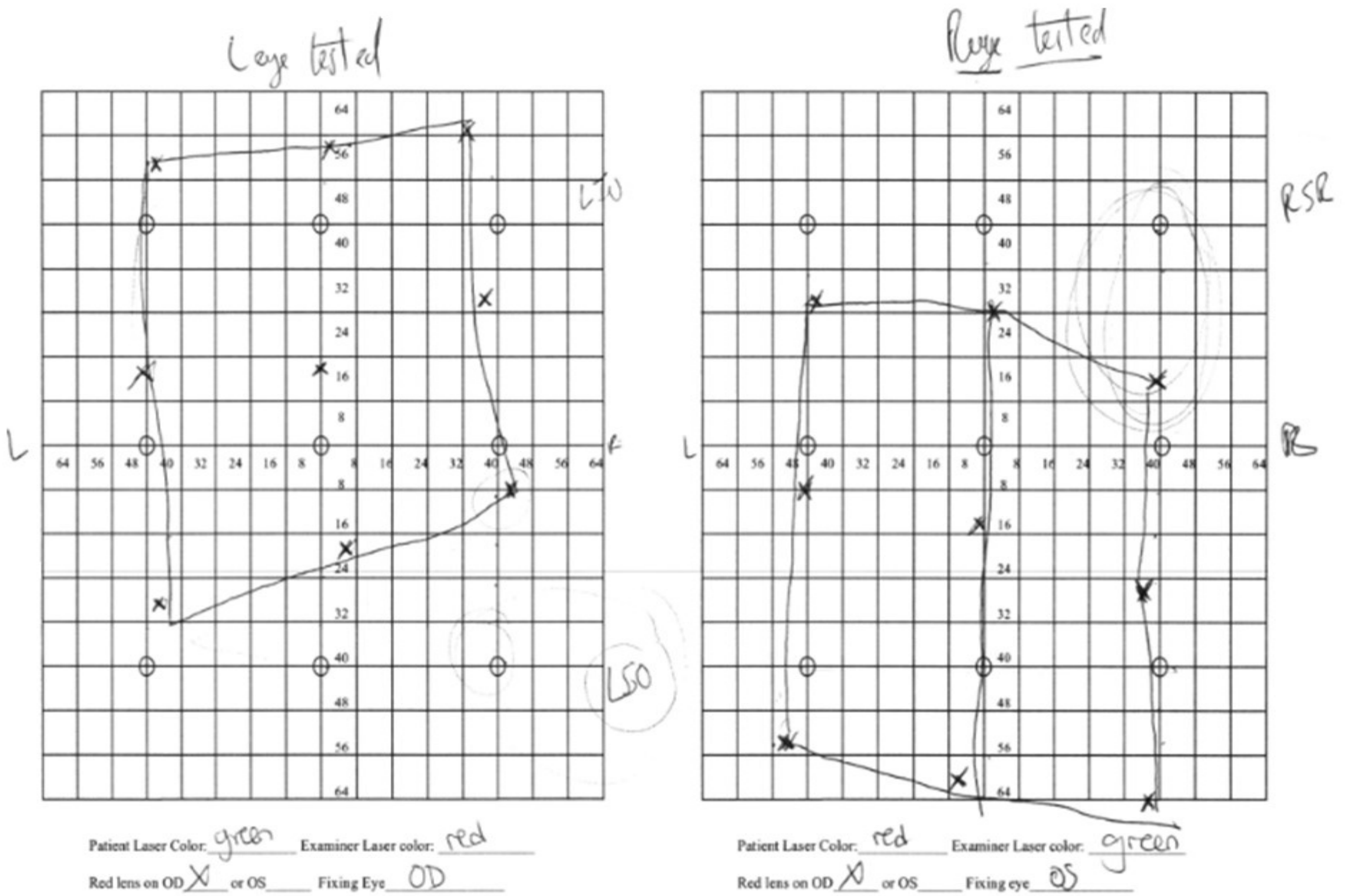

***Figure 1.** Hess-Lancaster testing. Note the two relatively equal sized fields and two underacting muscles. When the left eye was tested (right eye fixating), a LSO underaction and a LIO overaction were revealed. When the right eye was tested (left eye fixating), a RSR underaction and a RIR overaction were revealed.*

Table 2. Summary of Vision Therapy Activities

Phase 1: Monocular skills	Near/Far Hart Chart +/- Lens Flippers Pegboard Rotator
Phase 2: Bi-ocular/anti-suppression	Telebinocular Brock String Synoptophore GTVT (Red-Green Anti-Suppression Charts) Vectograms BOP/BIM training
Phase 3: Fusional ranges, stereopsis	Telebinocular Brock String Synoptophore Vectogram Aperture Rule Free-Space Fusion activities

Hess-Lancaster testing was performed in order to obtain a subjective measure of concomitancy in all positions of gaze. Figure 1 shows the patient's Hess-Lancaster testing, which revealed underaction of both the left superior oblique (LSO) and the right superior rectus (RSR) muscles. The size of the field of both eyes was relatively equal, which is characteristic of a longstanding deviation when using the Hess-Lancaster test. If the muscle paresis was new and confined to one eye, the test field of the eye with the paretic muscle would be smaller, while the other eye would have an expanded test field.[11]

When the left eye was tested (right eye fixating), the LSO underaction in down-right gaze was obvious, as was the overaction of the LIO in up-right gaze. When the right eye was tested (left eye fixating), the greatest underaction (noted in up-right gaze) corresponded to the RSR, and the greatest overaction (noted in down-right gaze) corresponded to the RIR. This result is expected in a CN IV palsy because of the interaction between Sherrington's law of reciprocal innervation and Hering's law of equal innervation. In down-right gaze with the right eye fixating, the LSO will underact; however, with the left eye fixating in down-right gaze, increased innervation is required to move the left eye into this diagnostic field of gaze. This causes an overaction of its yoked muscle (LIR) consistent with the prediction of Hering's law of equal innervation. In up-right gaze with the right eye fixating, the normal innervation sent to the RSR and LIO (yoked muscles in up-right gaze) will cause an overaction of the LIO because the LIO does not have substantial antagonistic action from the LSO, due to combined effects of the decreased tonus from the paretic LSO and the inhibitory effect due to Sherrington's law of reciprocal innervation. However, when the left eye fixates in up-right gaze, the innervation required to move the left eye into this diagnostic field of gaze is lower than usual because of the reduced antagonistic action from the LSO. Consequently, the RSR will display an underaction in accordance with the prediction of Hering's law of equal innervation.

A similar result could occur with a RSR palsy; however, noting the change in vertical deviation with head tilt can differentiate between these two muscles. Parks 3-step testing revealed an increase in vertical deviation with a left head tilt, which confirmed the LSO palsy in this patient.

Because the patient was highly motivated to begin vision therapy and had been functioning reasonably well, the decision was made to keep her in the same amount of prismatic correction with which she initially presented. The patient underwent 37 sessions of office-based vision therapy spanning just over a year due to breaks in her school schedule. Her compliance with home therapy was outstanding; she reported completing prescribed activities at least 4-5 days per week (not including her weekly in-office therapy session) for a total of at least 20 minutes per day. Our general therapy sequence included the following three phases: monocular, bi-ocular and anti-suppression, and fusion (horizontal and vertical). Late in the therapy, there was an added stage to work with vertical stress prisms. Table 2 summarizes the activities done in each session.

While many of the activities seem to be similar, especially between phases 2 and 3, it is important to note two points. First, throughout therapy, the patient was slowly weaned off vertical prism, and as a result, activities from earlier phases were repeated to retrain those skills with less prismatic correction. Secondly, substantial loading of activities took place throughout therapy. Examples of loading techniques include cognitive loading in the form of distractions (asking the patient questions while doing an activity, carrying on a conversation, recitation of math facts, etc.), the addition of movement or balance to fusion activities, and the addition of vertical stress prism. When a particular activity was mastered by the patient, added prisms and lenses were given to alter both the accommodative and vergence demands (both horizontal and vertical).

The patient's binocular system was re-evaluated every 8-10 sessions (with a long gap after 8 sessions due to the student's college summer vacation). Figure 2 shows a comparison of the patient's ocular alignment in right, left, and primary gazes before beginning vision therapy and after completing vision therapy. Table 3 summarizes the pertinent findings from each re-evaluation. At the end of 37 sessions, it was determined that in-office therapy could be discontinued while the patient continued some maintenance activities at home. AC's binocular system had improved enough that we were able to remove all prism from her spectacle correction.

Discussion

Accommodation and vergence movements are coupled. The response begins with a cue from the visual system, either blur in the case of accommodation or disparity in the case of vergence. This cue starts a fast, short-acting response (or "phasic" system), which stimulates accommodation and/or vergence movements. This fast, short-acting process is extremely energy intensive, so there is a secondary mechanism built in to maintain accurate accommodative and vergence demands over a longer period of time. This is the slow, long-

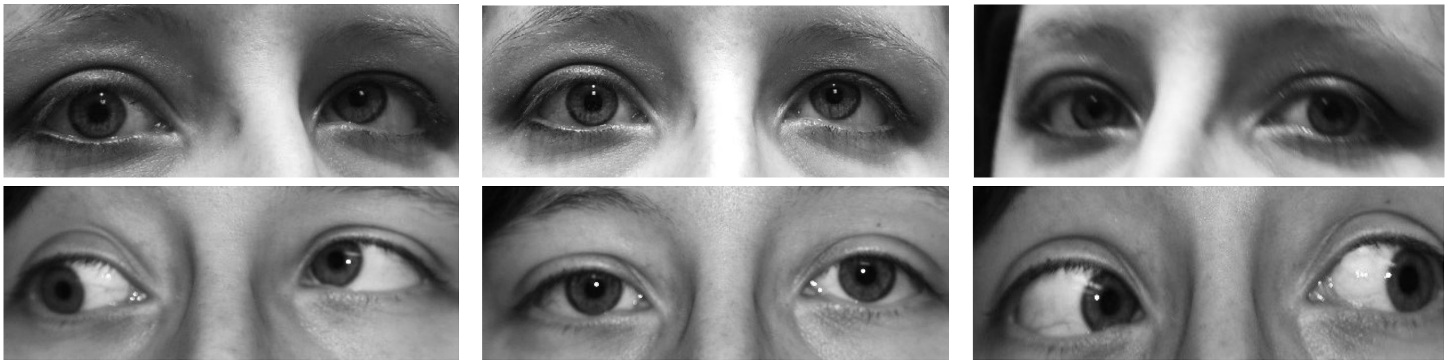

Figure 2. *Ocular alignment in right, primary, and left gaze prior to beginning vision therapy (top panel) and after completing vision therapy (bottom panel). Note not only reduced magnitude in primary gaze, but also increased range into right gaze.*

Table 3. Summary of Re-evaluation Findings throughout Vision Therapy

	Initial	**8 Sessions**	**26 Sessions**	**33 Sessions**
Habitual prism	7^{Δ}	7^{Δ} *reduced to 3^{Δ} at end of session	3^{Δ}	3^{Δ} *prism removed at end of session
Near alignment	12^{Δ} ILHT 6^{Δ} ILET	6-8^{Δ} CLHT 1^{Δ} XP	4^{Δ} ILHT (~30% tropia) 2^{Δ} XP	5^{Δ} ILHT (~30% tropia) 4^{Δ} XP
Worth 4 dot (bright lights)	Nose-10′: fusion 10-13′: alt. suppression/fusion 13′+: diplopia or OS suppression	Data not available	Nose-6″: diplopia 6″- 5′: fusion 5-8′: diplopia 8′+: fusion	Nose-8″: diplopia Fusion all other distances
Vertical vergence ranges (near)	OD supra: 5/4 infra: 10/6	OD supra: 2/1 infra: 17/16	OD supra: 2/-3 infra: 20+	OD supra: 2/0 infra: 20+
Horizontal vergence ranges (near)	BI: x/12/8 BO: x/20/15	Data not available	BI: 6/12/12 BO: x/5/1	BI: x/20/18 BO: x/4/3
Fixation disparity	7^{Δ} BD OS	4^{Δ} BD OS	1^{Δ} BD OS	None

acting, or "tonic" system. Many binocular vision problems arise from what Cooper refers to as a "leaky" tonic system.[6] Vision therapy has been shown to improve the caliber of the slow, long-acting aspect of both the vergence and accommodative systems.[4,7,8] The thought is that patients with binocular vision disorders rely heavily on their fast phasic systems because they lack robust tonic systems. As a result, a vicious cycle ensues. The initial response is made by the fast system. When the tonic system tries to take over, it is unable to do so. So, another response is made by the fast system, and the cycle repeats. Relying primarily on the fast system is energy-intensive and can even result in an imbalance between the accommodative and vergence systems. Thus, a binocular vision disorder arises. The subjective relief in symptoms that many patients experience after vision therapy is likely due to the improved caliber of the slow, long-acting system. Patients are no longer relying on the energy-intensive fast-acting system. By having a more robust tonic system, neural impulses that would be sent over and over to the fast system are now free to be used to make fine changes in the vergence and accommodative systems.[9]

Buildup of the slow system has also been shown to decrease fixation disparity, as seen in our patient.[6] In this patient, and in other reported cases in the literature, the magnitude of the deviation decreased as well.[3,4] The exact cause as to why this occurs is not well understood, but some studies report that the buildup of the slow system through active vision therapy may initiate a feedback mechanism that can change muscle length by the addition or depletion of sarcomeres.[9,10] A proposed mechanism for this is muscle adaptation to tonic vergence. A common binocular vision problem is a breakdown in fusional vergence, specifically with the fast system as described above.[9] Without a good fast fusional vergence response, other systems further down in this pathway continue to act without guidance. These feedback mechanisms continue to work; however, without fusion as the driving force, they may act in the opposite way and allow the muscles to position themselves in such a way as to eliminate the possibility of fusion. As a result, extraocular muscle length is altered so that the eye can comfortably stay in that position.[9] This is thought to be the cause of progressive deviations over time; a prime example of this is sensory exotropia.[9] However, if active vision therapy is done to strengthen and to increase fusional vergence ranges, this creates a cycle that first stimulates the fast fusional pathway, which drives the systems further down the pathway. The entire pathway is now working harmoniously towards a common goal, which is the maintenance of fusion. With accurate fusion, the neurological feedback mechanisms responsible for the addition or depletion of sarcomeres within the extraocular muscles are now stimulated to change muscle length towards the position that best fosters the maintenance of fusion.[9]

Conclusion

This case demonstrates the impact that optometrists can have on their patients. By offering vision therapy to a patient who has never had the option before, the patient's optometrist helped to change her visual experience profoundly. She now rarely experiences diplopia and is able to look further out into right gaze than she ever has been before. Prism has been completely removed from her spectacle prescription, and she has been fit in contact lenses. I will leave you with a few words from our patient that demonstrate how much optometrists change lives:

"I was one of those people that no one even considered for vision therapy. Every doctor just gave me a pair of glasses and sent me on my way. It wasn't until I was 21 that someone believed I could really improve my binocular vision. In just 3 months I was able to use both eyes more efficiently together, and see things I couldn't see before."

The greatest clinical pearl from this case is to let the patient decide whether they are motivated. As demonstrated by this case, patient motivation is key, and if the patient is willing to put in the work, together you can achieve amazing results!

References

1. Scheiman M, Wick B. Clinical management of binocular vision: Heterophoric, accommodative, and eye movement disorders, 4th edition. Philadelphia, PA: Lippincott Williams & Wilkins, 2014: 389-429.
2. Jackson D, Bedell HE. Vertical heterophoria and susceptibility to visually-induced motion sickness. Strabismus 2012;20(1):17-23.
3. Matheron E, Kapoula Z. Vertical phoria and postural control in upright stance in healthy young subjects. Clin Neurophysiol 2008;119(10):2314-20.
4. Frantz K, Otteson K. Vision therapy management for intermittent hypertropia with exotropia. Optom Vis Perf 2014;2(2):79-82.
5. Robertson K, Kuhn L. Effect of visual training on the vertical vergence amplitude. Am J Optom Physiol Optics 1985;62:659-68.
6. Cooper J. Orthoptic treatment of vertical deviations. J Amer Optom Assoc 1988;59:463-8.
7. Schor C. Fixation disparity: A steady state error of disparity-induced vergence. Am J Optom Physiol Optics 1980;57:618-31.
8. Patel N, Firth A. Vertical vergence adaptation does improve with practice. Optom Vis Sci 2003;80:316-9.
9. Guton D. Changes in strabismus over time: The roles of vergence tonus and muscle length adaptation. Binoc Vis Strab Q 2006;21:81-92.
10. Scott A. Change of eye muscle sarcomeres according to eye positions. J Pediatr Ophthalmol Strab 1994;31:85-8.
11. Griffin JR, Grisham JD. Binocular anomalies: Diagnosis and Vision Therapy, 3rd ed. Boston, MA: Butterworth-Heinemann, 1995:118-21.

Correspondence regarding this article should be emailed to Emily Aslakson, OD, at EmilyAslakson@ferris.edu.

Aslakson E. Reduction of magnitude and frequency of vertical strabismus through vision therapy. Optom Vis Perf 2016;5(4):141-5.

The online version of this article contains digital enhancements.

OPTOMETRISTS
CHANGE LIVES™

When Elly was about 4 years old, her mother, Anne, noticed she was having trouble meeting some physical and academic milestones.

"I thought things would work themselves out, but by age 5 she still couldn't recognize letters of the alphabet or jump up and down on both feet. This was very confusing for me, because I could see in other areas that Elly was very bright. She had an amazing memory and was really curious about her world," Anne said.

"Our optometrist helped me to understand exactly what Elly was seeing and not seeing and why. I found out Elly was unable to learn her alphabet because letters looked different to her each time she looked at them." Elly said, "At first I really couldn't see that well and I had to touch a lot of things to "see" them." She said when she started vision therapy she didn't think she would make it to the end. "It was a lot of work, but then I made it. By the time I was done it was way easy." Elly is now doing very well in school. "Before vision therapy I couldn't read at all or know my letters because they all looked a lot the same. And now I can see letters and read well. It's fun to read, especially Amelia Bedelia books."

"To put it simply, vision therapy has forever positively changed the course of my daughter's life."

Optometric Extension Program Foundation

GOOD-LITE® www.good-lite.com

HOYA