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Research Article

The Impact of Active Vision Therapy on Vision and Binocularity for Anisometropic Amblyopia Cases

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Abstract

Significance: Anisometropic amblyopia caused by uncorrected refractive error can eventually result in suppression of one or both eyes. The consequence of suppression may develop squint, loss of stereopsis, reduced contrast sensitivity and vision deprivation. Vision therapy as a novel approach treatment can contribute to improve the amount of stereo acuity by engaging young children in visual tasks under office-based therapy.

Purpose: The goal of this retrospective study is to evaluate the changes in vision and stereo acuity after active vision therapy. This retrospective analysis aimed to understand the efficacy of current treatment in managing anisometropic amblyopia in children within the specified age range, especially for those non-responders to conventional treatment.

Methods: Retrospectively, fifteen children were selected as non-responders to conventional patching treatment. The Inclusion criteria comprised children aged between 6 and 18 years, who had undergone cycloplegic refraction before prescribing glasses. Exclusion criteria included children with a history of previous occlusion therapy, as well as those presenting with strabismus and ocular pathologies.

Results: The mean visual acuity for the amblyopic eye before therapy was 0.48 logMAR. The post-therapy mean distance visual acuity of the amblyopic eye improved significantly, up to 0.013 logMAR. Before therapy, the subjects exhibited suppression in amblyopia. However, post-therapy intervention, there was a remarkable improvement in stereopsis, with a mean value of 125 ± 46 sec of arc after undergoing active office-based therapy combined with home exercises. Furthermore, no deterioration in vision and stereopsis was seen even after 3 months of any intervention to ensure no relapse of amblyopia and would be promising management of amblyopia.

Conclusion: Active vision therapy showed significant improvement in improving vision and enhancing binocularity reflected through stereo acuity.

Keywords: *Refractive Error; Anisometropic Amblyopia; Binocular Vision Disorder; Vision Therapy*

Introduction

Amblyopia is a unilateral or infrequently bilateral condition in which the best corrected visual acuity is poorer than 20/20(0) in the absence of any obvious structural anomalies or ocular disease. Anisometropic amblyopia is a form of amblyopia where due to different refractive errors present in one or both eyes. Anisometropic amblyopia is the most prevalent cause, accounting for 58.1% of all cases of amblyopia [1]. The degree of anisometropia is closely related to the severity of amblyopia [2]. The most convenient or standardized method to manage amblyopia is patching of a good eye to increase the functionality of the amblyopic eye. As a result of, a lack of compliance with patching therapy in children, we opted for an alternative approach by implementing active office-based therapy. This strategy acknowledges the challenges associated with patching compliance in paediatric patients [3]. Active office-based therapy could involve engaging children in interactive and stimulating exercises or activities to achieve therapeutic goals. This approach addresses the limitations posed by poor compliance. It enables a more interactive and dynamic approach that enhances treatment efficacy, resulting in boosting participation in the therapeutic process and improving the final outcome. We followed the approach outlined by Hess RF., *et al*. [4] to address anisometropic amblyopia, the most prevalent form of amblyopia. In our strategy in the amblyopia clinic, we carried out in divided phases, initially monocular phase, later integrating binocular exercises to restore binocularity [5]. The monocular phase comprised a sequential approach that emphasized target recognition, central and peripheral target awareness, fixation, pursuits, saccades, and visuomotor functions [6]. We employed various techniques like tracing, tracking training, and eye-hand coordination with variable stimulus size and contrast using the Sanet Vision Integrator (SVI) software. To enhance the stereopsis in amblyopia, we integrated Monocular Fixation on Binocular Field (MFBF) therapy with HTS Inet, Anti-suppression therapy, bilateral integration, and fine motor activities. The goal was to enhance visual concentration and improve visual searching, focusing intently on target segregation. The rationale behind the concept is that an amblyopic eye might be "awakened" by engaging these persisting binocular neural systems [6]. We targeted both dorsal and ventral pathways by stimulating the what and where mechanisms with variable contrast and stimulus size under Monocular Fixation on Binocular Field (MFBF) therapy. Most of our therapy centered on binocular training is expected to reduce lateral inhibition in the brain, which is the neural basis for the strategy. Most of our therapy centered on involving the brain which processes visual information. Amblyopia causes major pathological changes in the primary visual cortex and lateral geniculate nucleus like shrinkage of cells and neuronal loss in the primary visual cortex. Our therapy involves brain processing to establish binocularity which is limited with the patching therapy [7,8].

Methodology

Between September 2023 and April 2024, a retrospective study was conducted at the paediatric ophthalmology department of Pradyumna Bal Memorial Hospital, KIMS, Bhubaneswar. The study was conducted under the Tenets of the Declaration of Helsinki. The study aimed to investigate anisometropic amblyopia in children. Fifteen children (7 girls and 8 boys) were selected based on inclusion criteria. The inclusion criteria comprised children aged between 6 and 18 years, who had undergone cycloplegic refraction before prescribing glasses with anisometropia amblyopia {anisometropia > 1.5 Dioptre (spherical or spherical equivalent) or the difference in astigmatism > 1.5 D with no measurable strabismus}. Additionally, these children showed no improvement in vision despite undergoing patching therapy for a three-month period as part of their regular treatment protocol. Exclusion criteria included children with a history of previous occlusion therapy, as well as those presenting with strabismus or strabismic amblyopia. Children with any ocular pathology that could inherently cause visual impairment were also excluded from the study. This retrospective analysis aimed to understand the efficacy of current treatment in managing anisometropic amblyopia in children within the specified age range, focusing on those who did not respond to conventional therapies such as patching. This retrospective analysis aimed to understand the efficacy of current treatment in managing anisometropic amblyopia within the specified age range, centering on those non-responders to patching therapy. Our approach encounters the neural basis of amblyopia for binocular stability.

Baseline examination

During the first baseline examination for all subjects, unaided visual acuity was tested at a 3-meter distance under room illumination and recorded in the logMAR unit. Dry refraction was performed using the Heine Beta streak retinoscope. A pupillary examination was performed with a swinging flashlight, and subjects with any abnormal pupillary reflex were excluded. Using a slit lamp biomicroscope, we examined each subject's eyelashes, conjunctiva (palpebral, bulbar, fornix), and puncta with a regurgitation test. The sclera and each layer of the cornea were examined using appropriate magnification techniques. Anterior chamber grading was conducted using the van Herrick grading system, with grade 4+ considered normal for our subjects. Additionally, the anterior chamber reaction was assessed using a conical beam, and subjects with cells and flare were excluded. Goldmann applanation tonometry was performed for each subject after topical application of Proparacaine 0.5% and a sterile fluorescein strip soaked with one drop of saline water applied to the inferior conjunctiva in both eyes prior to intraocular pressure measurements. Subjects with intraocular pressures between 11 - 21 mmHg were considered normal. The Hirshberg corneal reflex test was performed to exclude subjects with manifest deviation. Extra-ocular motility testing was conducted with a torchlight, including only those with full, free, painless motility in all cardinal gazes.

Refractive error was confirmed following administration of the cycloplegic drug, specifically, the commercially available cyclopentolate 1%, administered twice at 15-minute intervals. After 40 minutes, retinoscopy was performed using the Heine Beta 200 retinoscope to obtain the gross retinoscopy value. Subsequently, post-cycloplegic autorefractometry was performed with the Potec PRK-7000 autorefractor. Retinoscopy values were recorded after deducting tonus allowance (+0.75D) added to the working distance (+1.50D). Upon full dilatation, an examination of the posterior segment was conducted using a slit lamp with a 90D lens and a binocular indirect ophthalmoscope with a 20D lens. Subjects with any crystalline lens changes, mainly opacities or vitreous opacity were noted. Optic nerves with distinct margins, a healthy rim disc, and cupping following the Inferior-Superior-Nasal-Temporal (ISNT) rule were considered within normal limits. An arterio-venous ratio of 2:3 was considered normal.

All subjects were instructed to return after one week for a post-mydriatics test. During this visit, subjective acceptance was assessed, and glasses were prescribed. The next follow-up was conducted after three months, during which the vision was rechecked. Depending on the severity of amblyopia, patching therapy was prescribed according to the PEDIG study [9] group's recommendations. Only participants whose parents reported poor patching compliance and who did not exhibit any improvement in visual acuity after three months of follow-up were included in the study. Stereopsis, Worth four dot test and refractive error assessment were conducted before starting active office-based vision therapy. Stereo-acuity test was performed with Randot stereo card with polarized glasses at near and distance, stereo acuity values <400 seconds of arc were recorded as Absence of stereopsis. Worth Four dot test with red-green goggles was assessed to verify suppression in the amblyopic eye. The vision therapy protocol followed is listed in table 1.

Activity	Description
Pursuits	
Visual tracing	To trace along the line until the end of the line
Target Recognition	
Monocular fixation in binocular field (MFBF)	To perceive a target in low contrast background
Saccades	
Saccadic fixator	To move along as visual stick ups attached to fixator lights up.

Anti Suppression	
Manual cheiroscope	To trace geometrical figures under binocular conditions in order to improve binocular stability
Accommodation	
Hart Chart	To shift and able to successfully clear the near chart at 3 inches and the far Hart chart 10 ft
Vergence and Stereopsis	
Variable (red/green) tranaglyph	To establish fusion, float with the absence of suppression

Table 1: *Vision therapy activities.*

Active office-based vision therapy was then administered for one hour daily for thirty sessions. After completion, all subjects were re-evaluated, and significant improvements were observed in vision and stereopsis. The office-based exercises were then tapered off, and home-based anti-suppression exercises with red-green filters, bar readers and Hart charts were prescribed for one hour daily. Subjects followed the protocol of weekly thrice for the next month, weekly twice for the following month, and weekly once for the last month. At the final visit, visual acuity and stereopsis remained stable, with no deterioration noted. Subjects were advised to discontinue home-based exercises and return after one month. Reassessment of the individuals' cycloplegic refraction, stereopsis, and vision at the one-month visit revealed no discernible changes in any of them.

Result

All the data were compiled and sorted properly and the quantitative data were analyzed statistically by using Statistical Package for Social Science (SPSS-25). Pearson's correlation coefficient (r) test was performed to assess the correlation between the amount of anisometropia and the distance vision for the amblyopic eye. The study analyzed a cohort of 15 subjects with amblyopia, with a mean age of 9.93 ± 2.76 years. Among these subjects, there were 8 males and 7 females. In this study, the mean visual acuity for the amblyopic eye was 0.48 logMAR. The higher logMAR value indicates poorer vision. Contrastingly, the mean visual acuity for the fellow eye, or the "sound eye," was recorded as 0 logMAR, indicating normal vision. This disparity highlights the characteristic asymmetry in visual acuity commonly observed in amblyopic individuals. In this study, the average amount of anisometropia between the amblyopic eye and the fellow eye was calculated to be 3.58 ± 2.17 dioptres (D). This study irrespective of age and gender, shows significant improvement in visual acuity and stereo acuity with active based vision therapy. The results revealed statistically significant ($p < 0.001$) improvement in both distance and near visual acuity following the therapy intervention as shown in chart 1. Overall, the mean stereo acuity gain in all subjects was significantly higher ($p < 0.001$) post therapy. However, post-therapy intervention, there was a remarkable improvement in stereopsis, with a mean value of 125 ± 46 secs of arc. The refractive error (spherical equivalent) difference between two eyes along therapy indicates periods of improvement/stable patterns shown in chart 2. Furthermore, the study investigated the sustainability of the observed improvement in mean visual acuity and stereopsis. Overall distribution for distance vision in amblyopic eye before therapy and refractive error on analysis stated central tendency across the range of values as shown in chart 3. Table 2 illustrates the changes in visual acuity for distance and near, as well as stereopsis, before and after the intervention, along with corresponding statistical significance (P values < 0.005). Table 3 illustrates the positive correlation between the amount of anisometropia and the mean visual acuity of the amblyopic eye for distance. The amount of anisometropia was significantly correlated $r = 0.519$, with the mean visual acuity of amblyopic eye for distance vision.

		Mean ± SD	Median (Q1-Q3)	p-value#
Age		10 ± 3	10 (7-13)	
Distance Vision (OD)	Before	0.3 ± 0.3	0.4 (0.0-0.6)	0.004
	After	0.0 ± 0.1	0.0 (0.0-0.0)	
Distance Vision (OS)	Before	0.1 ± 0.2	0.0 (0.0-0.3)	0.038
	After	0.0 ± 0.0	0.0 (0.0-0.0)	
Near vision logMAR (OD)	Before	0.5 ± 0.2	0.4 (0.3-0.6)	0.005
	After	0.3 ± 0.0	0.3 (0.3-0.3)	
Near vision logMAR (OS)	Before	0.4 ± 0.2	0.3 (0.3-0.6)	0.041
	After	0.3 ± 0.0	0.3 (0.3-0.3)	
Stereopsis	Before	<400 secs of arc	+/-	NA
	After	125 ± 46	100 (100-140)	
Refraction (OD)		-4.8 ± 4.0	-3.0 (-7.0--2.5)	0.211
Refraction (OS)		-3.3 ± 2.7	-3.0 (-4.0--1.5)	

Table 2: *The comparison between visual acuity and stereopsis before and after active therapy intervention.*

#: Related-Samples Wilcoxon Signed Rank Test.

Correlations		Distance Vision (Before)	Refraction difference
Distance Vision, Before	Pearson Correlation	1	.519*
	p-value		0.047
Refraction_difference	Pearson Correlation	.519*	1
	p-value	0.047	

Table 3: *The correlation between the amount of anisometropia and the refractive error difference for amblyopic eye.*

**: Correlation is significant at the 0.05 level (2-tailed).*

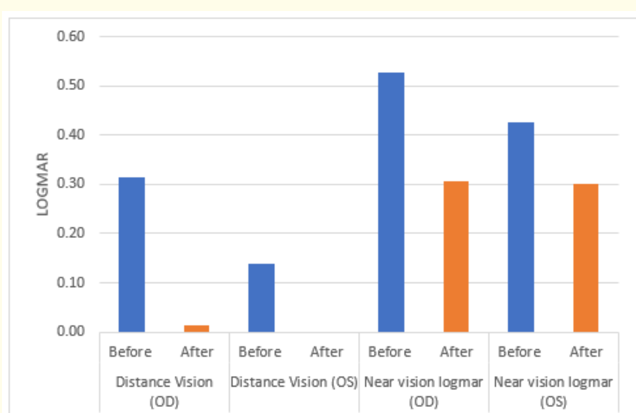

Chart 1: *Chart 1 shows the pre and post-distance and near visual acuity in Log Mar format for the right eye (OD) and the left eye (OS) following therapy.*

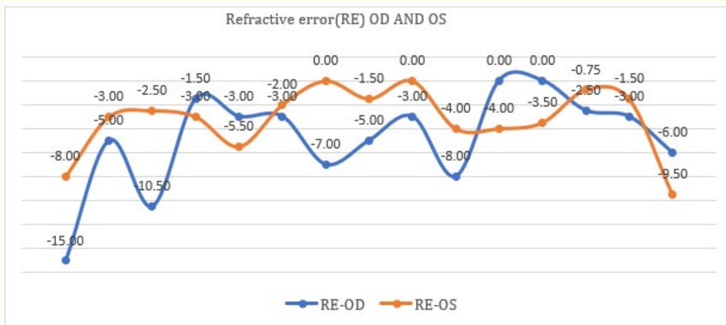

Chart 2: *Chart 2 shows the refractive error (spherical equivalent) for the right eye (OD) and the left eye (OS) following therapy.*

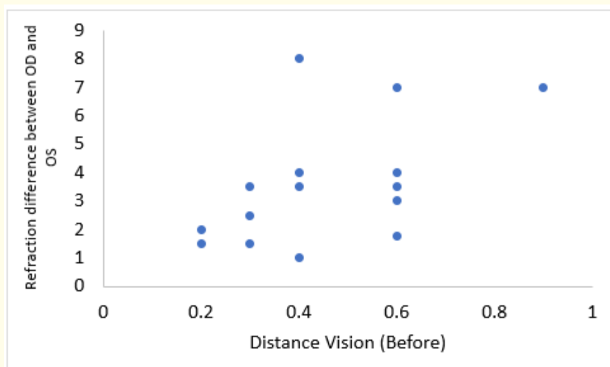

Chart 3: *Chart 3 shows distribution of distance vision for amblyopic eye and the amount of refractive error.*

Discussion

Refractive amblyopia is the most prevalent cause of amblyopia, with a good prognosis compared to other forms of amblyopia. Traditional amblyopia therapy with spectacle correction followed by patching often results in residual amblyopia in older children. The association of binocularity is rare with patching therapy, more prominent in non-compliant patients and non-responders. This suggests an opportunity to explore binocular therapies as an alternative approach, as well as compared to standardized treatment. Introducing a task that involves the integration of the two stimuli simultaneously in binocular vision yields the resultant therapy effect. Active vision therapy including orthoptic exercises addresses the behavioural definition of amblyopia [7], which states that amblyopia is a binocular disorder manifested monocularly. The sequential approach therapy included different target sizes with variable contrast, involving tracing and tracking training through Sanet Vision Integrator software [6]. Monocular fixation in the binocular field (MFBF) therapy with the HTS Inet and saccadic therapy were employed [10]. All the subjects were advised to perform red/green bar reading with red/green anaglyphic eyeglasses for 1 hour per day to allow dichoptic presentation for home-based support. This study involving an alternative approach reported significantly higher gains in mean distance, near vision and stereo acuity, especially in non-responders to patching therapy, suggesting that be a promising treatment for amblyopia. Active office-based therapy could involve engaging children in interactive and stimulating exercises or activities to achieve therapeutic goals while incorporating exercises for improving fusion and stereopsis. Traditional management of amblyopia relies upon good visual acuity but lacks fixation instability and poor stereoscopic vision, resulting in binocular visual dysfunction. Hence, recovery of binocular vision is based on exercises for fixation, pursuits, saccades, visuomotor, spatial awareness and eye-hand coordination. This study aimed to demonstrate good visual acuity parallel to the recovery of binocular vision and steady fixation by diminishing the chance of residual amblyopia resulting in positive binocularity in both eyes.

Hence, all the retrospectively selected candidate has been followed after one month of no intervention, and there was no deterioration of best corrected visual acuity as well as in binocular vision parameters, demonstrating the effectiveness of our combined treatment strategy for this case. Amblyopia is a neural disorder leading to abnormal neuronal competition in the primary visual cortex, and to address this, our therapy approach involves the visual cortex (colour, contrast, visual field and visual acuity) but also the frontal lobe (executive function, problem-solving, organizing and decision-making) and temporal and parietal lobes, respectively by tasks involving laterality, number, and letter recognition in variable sizes in different loci [11]. Through our vision therapy protocol, our aim was to maximize monocular visual acuity first, then include binocularity tasks as guided by Mitchell Scheiman [12].

In previous studies, Park., *et al.* [13] noted a significant 94% enhancement in visual acuity through occlusion therapy among children aged over 9 years and postulated that the age factor was closely related to the successful outcome of vision therapy. The results also suggested that beyond the plastic period of treating amblyopia lasts for a longer period of recovery of visual acuity over upper limit for treatment. Rinkal Suwal., *et al*. [14] noted significant improvements in mean acuities and stereoacuities in both active vision therapy group and patching groups and concluded that active vision therapy had a better impact than patching therapy in terms of improvement in stereoacuity, suggested that active vision therapy combined with planned home therapies was higher than conventional patching alone regardless of severity and type of amblyopia in children.

Another review article collateral to new advances in amblyopia therapy concluded that novel approaches like dichoptic training, and perceptual learning have shown sustained effect under extensive research and summarized that investigations make it likely to modify and adapt novel approaches to generate creative, engaging amblyopia therapies that benefit children and adults too [15]. The dichoptic treatment presents two targets to each eye and derives its effect from binocular visual function with improvements in binocularity and vision. Another practice of perceptual learning for various visual tasks has reportedly shown improvement in orientation discrimination, stereoacuity and contrast sensitivity.

In our study, we observed an even more remarkable outcome, with a 100% improvement rate. Furthermore, 93.33% of the participants achieved complete visual recovery. They attained a vision of up to 0 logMAR for distance and improved stereopsis, gaining binocularity and suppressing the chance of reverse amblyopia. The study summarizes that active based therapy combined with home exercises has proven to be more effective than conventional therapies.

Limitations of the Study

The present report demonstrates the clinical benefits of active vision therapy in young children. However, the limitation of the present study is retrospective in design, and so the absence of a control group leads to poor control over the exposure factor.

Conclusion

The study highlights significant reluctance among individuals towards undergoing patching therapy for amblyopia. This reluctance could stem from various factors, such as the discomfort of wearing an eye patch, social stigma, or concerns about the effectiveness of the treatment. In response to this reluctance, there has been a shift towards embracing non-invasive approaches for amblyopia management. Our approach involves a range of exercises aimed at improving accommodation and convergence. Another aspect of this approach is dichoptic therapy, which involves presenting different images to each eye simultaneously. This technique helps to overcome suppression and encourages both eyes to work together. Anti-suppression therapy specifically targets the suppression mechanism, aiming to restore binocular vision. Additionally, pursuit and saccade training are incorporated into the therapy regimen. By addressing these aspects of binocular vision, our therapy attained to achieve precise, comfortable, and sustainable binocular vision in individuals with amblyopia. Overall, this non-invasive approach to amblyopia management offers a promising alternative to traditional patching therapy, addressing both the visual deficits and the barriers associated with treatment. We recommend further study with a larger sample size and prospective nature is necessary to explore the appropriate role of active vision therapy and implement it, to the larger population.

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