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Effectiveness of Clinic-Based Vision Therapy for Non-Strabismic Binocular Vision Anomalies (NSBVA) Among Adults

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ABSTRACT

Background: To assess the effectiveness of clinic-based vision therapy in adults with non-strabismic binocular vision anomalies.

Methods: This retrospective study was conducted between January 2018 and December 2021 at a tertiary eye care center in Southern India. Elec-tronic medical records of adults aged 30 years and above diagnosed with non-strabismic binocular vision anomalies, and who underwent a mini-mum of five sessions of clinic-based vision therapy (VT), were reviewed. Clinical parameters of vergence and accommodation were analyzed pre and post-therapy.

Results: A total of 44 participants meeting the inclusion criteria were included in the study, with a mean (SD) age of 36 (±6) years. The partic-ipants were categorized into two groups based on the completion of either five sessions (Group A) or ten sessions (Group B) of vision therapy (VT). The overall median (IQR) for near phoria was -4 (-8 to 0) PD, the near point of convergence break point was 8 (4 to 12) cm, fusional conver-gence amplitude for near was 25 (14 to 30) PD, and binocular accommo-dative facility and amplitude were 3 (0 to 6) cpm and 9 (7 to 10) D, respectively.

Conclusion: Clinic-based vision therapy is efficacious in managing non-strabismic binocular vision anomalies in adults.

1. Introduction

Non-strabismic binocular vision anomalies have been predominantly reported among young adults (Cacho-Martínez, 2010), with sparse data available for older adults. Convergence insufficiency (CI) has been reported as the most common among school children, followed by accommodative dysfunctions (Hussaindeen *et al.,* 2017) in India. The estimated prevalence of CI, reported in a review, ranged between 2.25% to 33% globally (Cacho-Martínez, 2010), determined by diagnostic criteria and ethnicity-specific normative data. A higher proportion of NSBVA, 51%, has been reported among adults aged sixty to eighty years (Leat *et al.,* 2013). The standard treatment for NSBVA is clinic-based vision therapy with home reinforcement (Barnhardt *et al.,* 2012; Scheiman *et al.,* 2005b), a recommendation supported by various studies. The efficacy of vision therapy has been well-established and verified through functional magnetic resonance imaging (fMRI) measures, showing improvements observed at the higher centers of the brain (Scheiman *et al.,* 2005a; Alvarez *et al.,* 2010, 2019, 2020). Around 60% of adults in the presbyopic age group diagnosed with convergence insufficiency have shown improvements after clinic-based vision therapy (Birnbaum, 1999). However, there is a lack of evidence to understand the effectiveness of clinic-based vision therapy on other subtypes of NSBVA among older adults. Hence, this study aims to report the efficacy of clinic-based vision therapy among older adults diagnosed with NSBVA.

2. Methodology

This retrospective review of a clinic-based sample was conducted at a Binocular Vision Clinic in a tertiary eye care center in South India. The study received approval from the Institutional Research Board and Ethics Committee and adhered to the declarations of Helsinki. Participants aged between 30 and 60 years, who presented to the binocular vision clinic between January 2018 and December 2021, were included in the analysis. Participants aged 30 years and above, experiencing asthenopia related to near work and referred from the outpatient department to the binocular vision clinic, were identified from electronic medical

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records. All participants underwent a thorough ophthalmic examination before the binocular vision assessment. Those diagnosed with neurological or retinal pathology were excluded from the analysis. Additionally, participants who did not complete the assigned vision therapy sessions at the clinic or were unable to attend the post-vision therapy assessment were excluded.

The binocular vision assessment followed the standard protocol (Scheiman *et al.,* 2014). Vergence parameters comprised the near point of convergence, fusional vergence amplitudes, and vergence facility. Accommodative parameters encompassed the near point of accommodation, monocular and binocular accommodative facility. Notably, accommodative facility was assessed only for participants aged 35 years or younger. Based on binocular vision assessment, the diagnosis of NSBVA was made (Scheiman *et al.,* 2005a), and participants were advised clinic-based vision therapy. The binocular vision assessment was repeated after a 6-week refractive error adaptation period for participants who were wearing glasses for the first time or experienced a change in refraction by more than 0.50 Dioptre. Office-based vergence and accommodation therapy were administered following the therapy protocol provided by the Convergence Insufficiency Treatment Trial (CITT study group, 2008). Each vision therapy session lasted for an hour, and participants were assigned to attend a minimum of five sessions and a maximum of ten sessions consecutively.

3. Results

The study included a total of 44 participants, with a mean (SD) age of 36 (±6) years, of whom 22 (50%) were female. The mean (SD) of spherical equivalent refractive error was -1.37 (±2.87) D in the right eye, with a range of (-12.75 D to +2.25 D), and -1.23 (±2.61) D in the left eye, with a range of (-10.00 D to +2.37 D). Out of the 44 participants, 15 were found to have emmetropia. The dataset was divided into two groups based on the hours of clinic-based vision therapy: group A comprised 30 participants, and group B comprised 14 participants who had completed five and ten sessions of vision therapy, respectively.

3.1. Group A

Out of the 30 participants, 17 (56.7%) were non-presbyopic (age range 30 to 35 years), and 14 (43.3%) were in the presbyopic age group (age range >35 to ≤60 years). The median (IQR) age of the non-presbyopic group was 32 (30 to 33) years, with 47.1% female participants, and 38 (37 to 41) years in the presbyopic age group, with 53.9% female participants. The distance magnitude of phoria in group A ranged from orthophoria to 20Δ exophoria, and near phoria ranged from 4Δ esophoria to 18Δ exophoria. Among the 30 participants, 12 (40%) were diagnosed with convergence insufficiency, followed by accommodative infacility in 10 (33.3%) participants. Two (6.7%) participants were diagnosed with convergence excess (CE), 1 (3.3%) with divergence excess (DE), 4 (13.3%) with fusional vergence dysfunction (FVD), and 1 (3.3%) with basic exophoria. In the non-presbyopic age category, out of 17 subjects, 10 (58.8%) were diagnosed with accommodative infacility, 3 (17.6%) participants with convergence insufficiency (CI), and other subcategories of NSBVA. Among the 13 subjects in the presbyopic age category of group A, 9 (69.2%) participants were diagnosed with CI.

3.2. Group B

The median (IQR) age of the subjects was 37 (32 to 41) years. Out of 14 participants, 7 (50%) were female. Of 14 participants, 7 (50%) were categorized under non-presbyopic age group with 3 (42.9%) female participants. The measured distance and near magnitude of phoria was ranging from orthophoria to 20Δ exophoria and orthophoria to 18Δ exophoria, respectively, in group B. Out of 14 participants, 6 (42.9%) were diagnosed to have CI, followed by accommodative infacility in 4 (28.6%) participants. Of 7 non-presbyopic participants, 4 (57.1%) had been diagnosed with accommodative infacility, and 1(14.3%) had CI. In the category of presbyopic age group, 5 (71.4%) participants had been diagnosed with CI. The binocular vision parameters of Group A and Group B Pre, post-vision therapy are represented in Table 1.

Table 1: Binocular vision parameters of Group A and Group B pre and post vision therapy.

Parameters	Pre –therapy Median (IQR) (Group- A)	Post- therapy Median (IQR) (Group- A)	P Value*	Pre- therapy Median (IQR) (Group- B)	Post-therapy Median (IQR) (Group-B)	P Value*
Stereopsis (arc sec)	250 (250-500)	250 (250-700)	0.528	250 (250-1000)	250 (250-700)	0.016
Distance Phoria (PD)	0 (0 to 0)	0 (0 to 0)	1.00	-3 (-11.5 to -0.5)	-3 (-11 to 0)	0.084
Near Phoria (PD)	-2 (-4 to 0)	0 (-5.5 to 0)	0.415	-8 (-11.5 to -4)	-3 (-6 to 0.5)	0.003

Near point of convergence break (cm)	8 (3 to 12)	6 (2.5 to 8.75)	0.103	8.5 (6.25 to 11.75)	7 (6 to 8)	0.119
Distance divergence amplitude break (PD)	8 (6 to 8)	8 (6 to 10)	0.020	8 (8 to 10)	8 (8 to 11.5)	0.137
Distance convergence amplitude break (PD)	14 (10 to 19)	20 (16 to 25)	0.001	11 (3 to 17.5)	21.5 (12.5 to 28.75)	0.008
Near divergence amplitude break (PD)	13 (12 to 16)	14 (12 to 15.5)	0.832	14 (12 to 14)	12 (12 to 14)	0.346
Near convergence amplitude break (PD)	25 (17 to 30)	30 (25 to 35)	0.001	25 (9.5 to 25)	30 (30 to 45)	0.004
Vergence facility (CPM)	10.5 (5.5 to 13)	11.75 (9 to 13)	0.045	9 (1.25 to 12)	12.25 (10 to 13.3)	0.008
Amplitude of accommodation - OD (D)	8.3 (6.7 to 10.6)	10 (8.3 to 11.1)	0.17	8.3 (7.2 to 10.6)	10 (8.7 to 11.1)	0.249
Amplitude of accommodation OS (D)	9.1 (6.6 to 10)	10 (8.3 to 11.1)	0.227	8.3 (7.7 to 10.3)	10 (8.9 to 10)	0.463
Amplitude of accommodation - OU (D)	9.11 (7.1 to 10.6)	10 (7.9 to 11.1)	0.179	9.1 (8.3 to 10.1)	10 (9.3 to 10.6)	0.176
Monocular accommodative facility- OD (CPM)	2.5 (1 to 4)	4.5 (1.25 to 8.5)	0.009	1 (0 to 7)	10 (3.25 to 11.25)	0.058
Monocular accommodative facility- OS (CPM)	2 (1 to 3.8)	4.5 (2 to 7)	0.012	5 (0.5 to 8)	10 (1.25 to 11)	0.463
Binocular accommodative facility- OU (CPM)	3 (0.75 to 6.5)	7 (3 to 8.25)	0.008	5 (0.75 to 6.75)	8 (4.25 to 11.5)	0.051

*Wilcoxon signed rank test, PD- Prism dioptre, D- Dioptre, CPM -cycles per minute

The Median (IQR) binocular vision parameters pre and post vision therapy. Post-vision therapy stereopsis of groups B has shown improvement (Wilcoxon signed-rank test P <0.05) after ten sessions of vision therapy. One participant in group A has reported crossed intermittent diplopia in the Worth Four Dot Test (WFDT) at pre-vision therapy sessions, which remained the same at post-vision therapy. However, the participant had no complaints of any diplopia in free spaces at pre and post-vision therapy. Out of 14 participants in group B, three participants had intermittent crossed diplopia, reported to fusion at post-vision therapy treatment.

4. Discussion

Previous studies have reported that the rate of binocular vision anomalies increases by around ten percent among older adults with age, and clinic-based vision therapy with home reinforcement has effectively eliminated convergence insufficiency (Leat *et al.,* 2013; Birnbaum, 1999). An RCT by the Convergence Insufficiency Treatment Trial (CITT) group described a significant improvement in the mean breakpoint of NPC after clinic-based vision therapy with home reinforcement among 221 school-going children (CITT study group, 2008). CI-related symptoms have also improved after post-vision therapy with home reinforcement among younger adults (Barnhardt *et al.,* 2012; Jang, 2017), as established by various authors. Clinic-based vision therapies are recommended as a treatment modality among school-going children and young adults (Scheiman *et al.,* 2005a; Alvarez., 2020) in recent past. Though many studies are concentrating on younger age groups, very few studies among older adults also put forward the clinic-based vision therapy with home reinforcement to effectively eliminate convergence insufficiency of around sixty percent (Birnbaum., 1999). Pejic et al. reported that distance stereopsis improves at post-vision therapy among intermittent divergence strabismus (Pejic, 2006). However, we did not find any gross changes in stereopsis after vision therapy between both groups.

The magnitude of near heterophoria was effectively improved after post-vision therapy among school-going

children (Convergence Insufficiency Treatment Trial Study Group (CITT) and older adults (Birnbaum, 1999), as established by various studies. In this report, we found a similar trend after post-vision therapy between group B (p=0.003). However, distance phoria did not show any statistically significant improvement between groups. This may be hypothesized that more sessions can be recommended to improvise distance phoria status. The median break point of near convergence showed improvement at post-therapy from 8 (3 to 12) cm to 6 (2.5 to 8.75) cm after five sessions and from 8.5 (6.25 to 11.75) cm to 7 (6 to 8) cm after ten sessions of vision therapy. Convergence amplitude between both groups had shown a significant raise in the break point of prism diopter after vision therapy. Alvarez et al. has reported remarkable improvement in convergence amplitude after the completion of sixty minutes of biweekly clinic-based vision therapy with ten minutes of home reinforcement for three days a week among adults with CI below 35 years of age (Alvarez., 2020). Another report among younger adults (Scheiman *et al.,* 2005a; Scheiman *et al.,* 2005b) also established the improvement in convergence amplitude at post-vision therapy. Similar trends were observed in the current study between both groups, distance (group A; p=0.001, group B; p=0.008) and near (group A; p=0.001, group B; p=0.004) respectively. Conrad et al. reported around 92 percent of improvement in vergence facility after vision therapy among adults with brain injury (Conrad J. S, 2017). A combination of 3Δ base-in and 12Δ base-out flippers was used to assess the vergence facility in that study. A similar combination of the prism was used to evaluate the vergence facility in this present study, and significant improvement was observed in outcome between groups, both groups (group A; p=0.04, group B; p=0.008).

Accommodative parameters of participants, such as amplitude of accommodation and accommodative facility, showed significant changes after vision therapy between groups. Monocular amplitude of accommodation improved to 10 (8.3 to 11.1) Dioptre (D) from 8.3 (6.7 to 10.6) D in the right eye (p= 0.17) and from 10 (8.3 to 11.1) D to 9.1 (6.6 to 10) D in the left eye (p= 0.22) respectively in group A. Group B also showed improvement in the amplitude of accommodation from 8.3 (7.2 to 10.6) D to 10 (8.7 to 11.1) D and from 8.3(7.7 to 10.3) D to 10 (8.9 to 10) D right (p= 0.24) and left eye (p= 0.46) respectively. Previous studies suggest that vision therapy is an efficacious option for treating accommodative dysfunctions, leading to improvements in both symptoms and clinical signs (Hussaindeen 2020). In a recent report on accommodative spasm has shown improvement in amplitude of accommodation and accommodative facility on accommodative flipper training after clinic-based vision therapy (Kumar P. P., 2022). The present report shows improvement in binocular accommodative facility between groups (group A; p=0.008, Group B; p= 0.051) at post-vision therapy. However, monocular accommodative facility showed statistically improved (right eye; p=0.009, left eye; p=0.012) in group A compared with group B. Existing studies and RCTs have been focused mainly on school-going populations or younger age groups to treat NSBVA (Convergence Insufficiency Treatment Trial Study Group (CITT), 2008; Scheiman *et al.,* 2005a; Scheiman *et al.,* 2005b) except very few concentrated on adult population. To the best of our knowledge, there has been no study focused on the effectiveness of clinic-based vision therapy among the older age population diagnosed with NSBVA. In this report, all patients of both the groups underwent sixty minutes of clinic-based vision therapy on consecutive days for six days a week. After completion of recommended hours of clinic-based vision therapy sessions, patients of both groups showed improvement in their binocular vision parameters. In comparison with group A, participants in group B who had administered ten sessions of clinic-based vision therapy showed effective improvement in their binocular vision parameters. The treatment protocol was followed based on the evidence among the non-presbyopic population (Scheiman *et al.,* 2005b). However, the major limitation of our report was retrospective, and the unequal number of participants in both the groups with a small sample size. However, as this area required more exploration, a prospective report can be recommended to understand the effects of clinic-based vision therapy on each subtype of NSBVA.

5. Conclusion

Clinic-based vision therapy is a viable management option for older adults diagnosed with non-strabismic binocular vision anomalies. To achieve effective management of these disorders, it is recommended to undergo a minimum of ten hours of clinic-based vision therapy.

6. Competing Interests

I have declared that no competing interests exist

7. Funding

Nil

8. Ethics Declaration

This study received approval from the institutional review board and Ethics committee, Study Code: 1001-2021-P

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