Original Article

Vision Therapy/Orthoptics among Three to Seven Year Old Children

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Abstract

Background: Vision Therapy/Orthoptics(VT/O) is a package of treatments that enables patients to achieve the maximum level of visual performance.The aim was to determine the effect of three months vision therapy/orthoptics on best corrected visual acuity (BCVA), fusion, stereopsis and ocular alignment in 3-7 year old children.

Materials and Methods: In this randomized clinical trial study, 80 children with amblyopia and/or non-paralytic horizontal deviations were randomly divided into intervention and control groups. Intervention group was treated by vision therapy/orthoptics for three months. These modalities included patch, red filter, sector patch, over minus lens, prism and synoptophore exercises. Controls were treated by only patching for the same period. Pre and post-treatment BCVA, fusion, stereopsis and alignment were compared. Visual performance was classified as excellent (BCVA≥20/30, deviation≤10pd and stereopsis≤70sec/are), acceptable (BCVA≥20/30, deviation ≤10pd and stereopsis 70 to 3000sec/are) and unsatisfactory (BCVA<20/30, deviation>10pd and no stereopsis).

Results: A total of 80 cases (56 girls and 24 boys) with the mean age of 5.6±1.4 years entered the study. Although more improvement of fusion and stereopsis was seen in the intervention group (P<0.001 for both groups), there was no significant differences in BCVA and alignment between two groups. Also the difference of visual performance was not statistically significant between two groups, whereas the improvement was significant in each group (P<0.001, for both groups).

Conclusion: Vision therapy/orthoptics treatment can be effective for improving sensory status in 3 to 7 year old children with amblyopia and/or strabismus. Further studies with larger sample sizes and focusing on accommodation and fusional amplitude are warranted.

Keywords: , Best Corrected Visual Acuity, Stereopsis, Vision Therapy, Orthoptics

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Introduction

"Vision" is to understand the meaning of what is seen and refers to a very complex process in the eye and brain. Half of the population over 3 years and 25% of school age children in the USA suffer from eye disorders including vision problems[1]. Although many of these disorders are related to refractive errors and should be treated by relevant glasses, there is some other accompanying functional problems in fixation, alignment, convergence, accommodation and fusion that also need vision therapy/orthoptics (VT/O)[1].

VT/O is a package of specific non-surgical treatments that eliminates some symptoms of the patients giving them a better quality of life and enabling them to

achieve their maximum level of visual performance. It helps a patient in three areas: 1) increasing visual acuity (VA), 2) improving the mechanical skills which results in more control of extra- and intraocular muscles, and 3) increasing perceptual skills of the brain[1]. These skills improve visual acuity (VA), fixation, focusing, eye alignment, convergence, binocular vision, eye hand coordination, spatial relation, peripheral vision, and form vision[1,2]. Many children with learning problems may benefit from VT/O due to their lower fusional amplitude and even a child with good VA may still have some of the mentioned visual system disorders which can be reduced by using VT/O. This therapy can be used at any age, although the purpose and outcomes vary according to the patient's age[2]. Different modalities of VT/O consist of eye patch, sector patch, red filter, over minus lens, prism, pencil push-up and synoptophore exercises which can be utilized according to patients' needs[2].

The history of vision therapy dates back to 1600-450 BC. For instance, face mask with special windows was applied to force the eyes being straight, which was similar to the current use of sector patch in VT/O[3]. Researchers have recently reported some promising effects of VT/O, using some new techniques[4,5]. In a pilot study on 9-18 year-old children with convergence insufficiency, an office-based VT/O using three modalities was more effective than office-based placebo VT/O and home-based pencil push-ups therapy[4]. However, there are still many unanswered questions regarding therapy particularly in young children. Considering various techniques with different combinations used in this field, the literature still lacks a consensus about the method of prescription, applicability, effectiveness, and durability of VT/O. Moreover, the assumed diversity in the patients' response with different ages suggests the need for additional studies.

In this study, we evaluated the effect of VT/O on best corrected visual acuity (BCVA), motor, and sensory status of children aged between 3 to 7 years old. We applied different combinations of VT/O according to patients' needs.

Methods

This randomized clinical trial study was performed on 80 children with BCVA of 20/20 to 20/200 among December 2012 to February 2013. The study protocol and its probable safety and efficacy were explained before recruitment. Informed consent was received from all patients' parents. The study was approved by the review board/ethics committee of the Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

We studied 56 girls and 24 boys with the age range of 3 to 7 years who had functional amblyopia and/or non-paralytic horizontal deviations. Cases with a history of trauma, strabismus surgery within the last 3 months, nystagmus, vertical deviation more than 5pd, any organic ocular disease, and mental disorders were excluded. We also excluded children who were unable to response to VA testing. Children were randomly divided into intervention and control groups, randomization performed by the Biostatisitician (MY) based on a Permuted-block randomization with varying block size of (2 to 6) using a computer program. By this way patients were manage by either VT/O or the standard method of patching, respectively.

A complete ophthalmic examination was performed for all enrolled children by a pediatric ophthalmologist. It included cycloplegic refraction, determination of BCVA by Snellen chart, checking of eye deviation by Krimsky and prism alternate cover tests, testing of fusion with Worth 4 Dot test and stereopsis by Titmus test. Amblyopia was defined as BCVA< 20/30 or the difference of BCVA between two eyes ≥2 lines. Strabismus was considered if eye deviation was more than 10pd in primary position. For all children, appropriate glasses were prescribed if needed. In the intervention group two or more modalities of VT/O according to patients' needs were applied for three months. The VT/O modalities in this study included:

1) Patch therapy of better eye for amblyopia therapy; 2 hours a day for 2 lines difference of BCVA between two eyes and 4 to 6 hours a day for more difference until achieving equal BCVA in both eyes. If there was eye deviation with no amblyopia, 1 or 2 hours patching of fixating eye or alternate patch in alternating fixation was applied.

2) Red filter over the glass of amblyopic eye during patch therapy for children with fixation disorder and

suppression of one eye.

3) Sector patch in medial or lateral sides of glasses for esotropic or exotropic cases, respectively to limit the eye movements in adduction or abduction. The edge of the sector patch did not cover the pupil area.

4) Over minus lenses of -2.00D in patients with intermittent exotropia for better controlling of their deviation.

5) Prism exercises half an hour, twice a week in patients with intermittent exotropia.

6) Synoptophore exercises, 15 minutes twice a week as an anti-suppression therapy in patients with ocular suppression and convergence exercises for cases with intermittent exotropia.

In control group only patch therapy as mentioned in VT/O modalities was performed after prescription of appropriate glasses.

For example if the child was exotropic and selected in the intervention group, modalities of patch, temporal sector patch, prism or synoptophore exercises and over minus lenses were indicated in his or her VT/O package treatment. If this child was selected as the control group, only patch therapy was indicated after prescribing appropriate glasses.

All parents were also asked to make their children play with computer games or do a form of near task such as drawing or reading 1 hour per day to enhance the effect of patch therapy and their perceptual skills training in both groups. All examinations were repeated after 3 months by the same ophthalmologist in both groups.

In this study patients with stereopsis ≤ 70, between 80 to 3000, and >3000 second of arc were considered as having central fusion, peripheral fusion and no fusion (suppression), respectively. Visual performance was classified as excellent (BCVA≥20/30, deviation≤10pd and stereopsis≤70sec/arc), acceptable (BCVA≥20/30, deviation≤10pd, and stereopsis 70 to 3000sec/arc) and unsatisfactory (subjects with BCVA<20/30, deviation>10pd and no stereopsis).

Statistical analysis. To describe data, we used mean±SD (range) and number (%). To evaluate differences between the two groups, we used the Mann-Whitney test, Chi Square and GEE analysis (Whenever the correlation of the eyes of a subject should be consider). To evaluate the changes within groups Wilcoxon Singed Rank test and MacNemmar test were used. All statistical analysis performed by SPSS (version 21, Armonk, NY: IBM Corp.).

Results

A total of 80 children with the mean age of 5.6±1.4 years (range: 3 to 7 years) entered the study. Of them, 56 (70%) were girls and 24 (30%) were boys. There were no statistically significant differences of age, sex, deviation angle and spherical equivalent (SE) between two groups. The numbers of anisometropic (P=0.009) and orthophoric (P=0.003) children were higher in the control group (Table 1).

The mean number of different modalities of VT/O used simultaneously in each individual case was 3 in the esotropic patients and 4 in the exotropic ones. The modalities used for esotropic cases were glasses, patch, sector patch, and red filter and for exotropic patients were glasses, patch, over minus lenses and orthoptics exercises using synoptophore and prism exercises. We did not apply red filter in exotropic and over minus lenses in esotropic cases (Figure 1). The selected combination depended on patients' conditions and requirements such as appropriate glasses for refractive errors and anisometropia, patching for amblyopia, and sector patching for the type of eye deviations.

The efficiency of VT/O treatment in the intervention group was observed on different considered items presented in table 2 which included improvement of BCVA (Figure 2), decreasing number of amblyopic children, changing of heterotropia to orthophoria (Figure 3), decreasing of the mean angle of deviations in both esotropic and exotropic children as well as improvement of fusion and stereopsis (Figure 4).

As table 2 shows, in the control group (only patch), improvement of BCVA, stereopsis and visual performance were observed and also there were less number of amblyopic children and significant reduction of the mean angle of deviation in esotropic children after treatment, as well.

In comparison with control group, the difference of fusion (P<0.001), stereopsis (P<0.001) and the mean angle of esotropic (P=0.001) and exotropic deviations (P=0.025) were statistically significant.

In addition all visual performances included BCVA, ocular alignment and stereopsis as defined in the

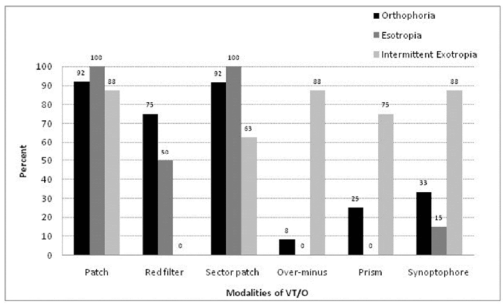

Figure 1. Different modalities of VT/O treatment applied in the intervention group for three types of alignment.

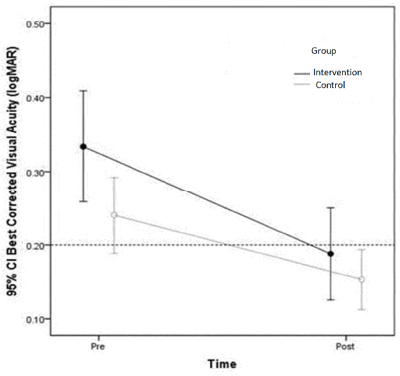

Figure 2. Pre and post BCVA in the intervention and control groups.

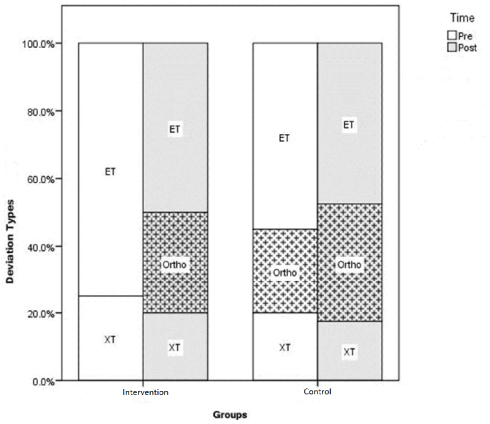

Figure 3. Pre and post alignment types in the intervention and control groups.

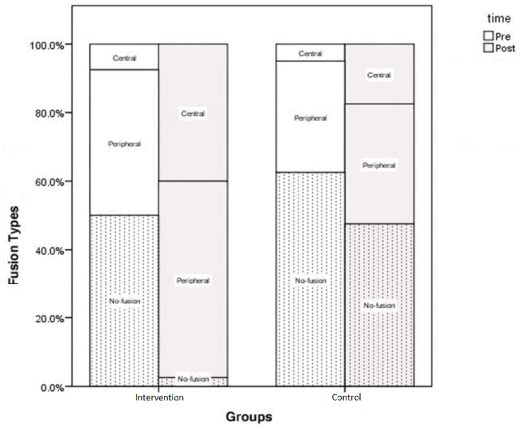

Figure 4. Pre and post VT/O stereopsis types in the intervention and control groups.

method section, were improved in both groups (P<0.001 for both), with no differences between two groups (Table 2).

Discussion

There are some reports of deficiencies in different visual performances of amblyopic and strabismic eyes; these might include abnormality in BCVA, accommodation, contrast sensitivity, fixation, binocular function, motion detection and vernier acuity, as well[6-12]. Therefore some eye care practitioners apply active VT/O to treat amblyopic patients indirectly through improving these visual functions[13-15].

This randomized clinical trial study was performed on 80 children with age range of 3 to 7 years old in two groups. Patch plus VT/O exercises for intervention group and only patch in the control group were applied.

Our study was limited to 3 to 7 year old children based on the fact that the age of 7 is considered as the "critical period" for visual improvement[16], whereas Preferred Practice Pattern of amblyopia by American Academy of Ophthalmology has recommended the possibility of amblyopia treatment up to age 10 years, successfully[17].

We treated our children for 12±2 weeks in order to complete the duration of amblyopia therapy (each course of therapy included one week patching for each year of age) and we prescribed two courses for children who did not achieve BCVA of 20/20 in their first course of amblyopia therapy.

Although BCVA improved significantly in both groups, there was no significant difference between two groups. It could be due to applying equal patch therapy in both groups. We could not ethically discontinue patch therapy since some children in the intervention group were amblyopic and the effect of VT/O modalities has been not clear, yet. In a literature review by Garzia et al, there have been many reports of favorable results using VT/O in patients who were

Table 1: Baseline characteristics of children in intervention and control groups.

Factors	Level	Total	Intervention group	Control group	P
Age (y)	mean±SD	5.6±1.4	5.7±1.6	5.4±1.2	0.116†
	median (range)	6 (3 to 7)	6 (3 to 7)	6 (3 to 7)	
Sex	Female	56 (70%)	31 (79.5%)	25 (62.5%)	0.097*
	Male	24 (30%)	9 (20.5%)	15 (37.5%)	
SE (D)	mean ± SD	2.33±2.55	2.37±1.92	2.3±3.07	0.890§
	M(Range)	2 (-6 to 8)	2 (-1.63 to 7.25)	2 (-6 to 8)	
Anisometropia>1.5 (D)		38(47.5%)	12(15%)	26 (34.5%)	0.009
Type of deviation	Orthophoria	10 (12.5%)	0 (0.0%)	10 (25.0%)	0.003*
	Esotropia	52 (65.0%)	30 (75.0%)	22 (55.0%)	
	Extropia	18 (22.5%)	10 (25.0%)	8 (20.0%)	
Deviation (pd)	mean ± SD	17.3±12.4	15.6±7.3	19.1±15.9	0.633†
	M (Range)	16 (0 to 50)	16 (4 to 35)	15 (0 to 50)	

SE: spherical equivalent; D: diopter; pd: prism diopter; M: mode; SD: Standard deviation; P: probability

* Based on Chi-square test; † Based on Mann-Whitney test; § Based on GEE analysis

poorly responsive to amblyopia occlusion therapy. In addition to patching in amblyopia treatment, the effects of VT/O on accommodative and fusional performance have been shown in literature[15]. Considering near VA and accommodative power, Rouse et al. suggested that VT/O could be an effective treatment[18]. Scheiman et al. revealed that near activities along with patching could improve VA for two lines or more after a period of 24 weeks even in children beyond 10 years old[19].

Evaluating the effect of VT/O on 96 patients with mean age of 18.1 years, Daum et al. showed a considerable improvement of VA, fusion, stereopsis, accommodation and near point of convergence[20]. Most of their patients (90%) obtained some symptom relief and about 53% had their objective and subjective problems totally solved during an average period of 3.7 weeks of VT/O. Their findings in terms of fusion and stereopsis are comparable with our results that showed significant differences between the intervention and control groups (P<0.001).

Both esotropia and exotropia changed to heterophoria in a significant number of our patients. This might be due to increased fusional amplitude through improved BCVA by patching and stereopsis by synoptophore exercises that provide more stable sensory and motor status. In a study on 74 patients, 52 with intermittent exotropia and 22 with convergence insufficiency, Asadi et al. demonstrated success rates of VT/O to be 83% and 100%, respectively [21]. Using fusional convergence training, Coopers et al. also showed a significant improvement in convergence amplitude of 7 adult patients with normal VA and peripheral fusion[22].

Scheiman et al. in study of randomized multicenter clinical trials on 47 cases demonstrated that office-based VT/O can significantly improve convergence amplitude and near point of convergence distance[4,5]. This effectiveness has also been demonstrated by Daum et al. in a study on 35 adult cases. Although this effect diminished after 3 weeks, it could be detected even after 6 months. They showed a lower success rate

Table 2: Pre and post treatment visual, motor and sensory status of the patients in the intervention and control groups.

				Total	Intervention	Control group	P
BCVA (logMAR) mean±SD		Pre		0.29 ± 0.29	0.33 ± 0.33 (0 to	0.24 ± 0.22 (0 to 0.7)	0.098§
		Post		0.17 ± 0.24	0.19 ± 0.28 (0 to	0.15 ± 0.18 (0 to 0.7)	0.464§
		Change		0.13 ± 0.15 (0 to	0.15 ± 0.18 (0 to 0.7)	0.11 ± 0.11 (0 to 0.4)	0.267§
		Within P‡			<0.001	<0.001	
Amblyopia (n%)		Pre		96□	47 (61.0%)	49 (61.3%)	0.985§
		Post		66 (41.3%)	30 (37.5%)	36 (45.0%)	0.424§
		Within P**			<0.001	0.007	
Deviation	Pre	Orthophoria		10 (12.5%)	0 (0.0%)	10 (25.0%)	<0.001*
		Heterotropia		70 (87.5%)	40 (100.0%)	30 (75.0%)	
			ET	52 (65.0%)	30 (75.0%)	22 (55.0%)	
			XT	18 (22.5%)	10 (25.0%)	8 (20.0%)	
	Post	Orthophoria		26 (32.5%)	12 (30.0%)	14 (35.0%)	0.633*
		Heterotropia		54 (67.5%)	28 (70.0%)	26 (65.0%)	
			ET	39 (48.8%)	20 (50.0%)	19 (47.5%)	
			XT	15 (18.8%)	8 (20.0%)	7 (17.5%)	
		Within P**			<0.001	0.125	
Mean Deviation (pd)		Pre		17.3 ± 12.4	15.6 ± 7.3 (4 to	19.1 ± 15.9 (0 to 50)	0.633†
		Post		8.2 ± 8.2 (0	8.8 ± 5.9 (0 to	7.6 ± 10 (0 to 45)	0.049†
		Change		9.1 ± 11.45	6.78 ± 5.91 (0 to	11.43 ± 14.82 (-43 to	0.131†
		Within P‡			<0.001	<0.001	
	ET	Pre		19.6 ± 11.7	15.2 ± 7.6 (4 to	25.6 ± 13.6 (8 to 50)	0.016†
		Post		8.8 ± 7.5 (0	8.5 ± 6.3 (0 to	9.1 ± 9 (0 to 35)	0.808†
		Change		10.83 ± 10.2	6.67 ± 6.5 (0 to	16.5 ± 11.65 (0 to 42)	0.001†
		Within P‡			<0.001	<0.001	
	XT	Pre		20.4 ± 10 (2	16.9 ± 6.3 (6 to	24.9 ± 12.4 (2 to 40)	0.059†
		Post		11.3 ± 9.7 (0	9.8 ± 4.7 (0 to	13.1 ± 13.9 (0 to 45)	0.929†
		Change		9.17 ± 15.48	7.1 ± 3.9 (0 to	11.75 ± 23.42 (-43 to	0.025†
		Within P‡			0.007	0.161	
Fusion (n%)		Pre		34 (42.5%)	17 (42.5%)	17 (42.5%)	>0.99*
		Post		56 (70.0%)	38 (95.0%)	18 (45.0%)	<0.001*
		Within P**			<0.001	>0.99	
Stereopsis (n%)		Pre	Central	5 (6.3%)	3 (7.5%)	2 (5.0%)	0.525*
			Peripheral	30 (37.5%)	17 (42.5%)	13 (32.5%)	
			Absent	45 (56.3%)	20 (50.0%)	25 (62.5%)	
		Post	Central	23 (28.8%)	16 (40.0%)	7 (17.5%)	<0.001*
			Peripheral	37 (46.3%)	23 (57.5%)	14 (35.0%)	
			Absent	20 (25.0%)	1 (2.5%)	19 (47.5%)	
		Within P‡			<0.001	0.008	
Visual performance		Pre	Excellent	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.238†
			Acceptable	7 (8.8%)	2 (5.0%)	5 (12.5%)	

	Unsatisfactory	73 (91.3%)	38 (95.0%)	35 (87.5%)	
Post	Excellent	15 (18.8%)	7 (17.5%)	8 (20.0%)	0.923†
	Acceptable	21 (26.3%)	11 (27.5%)	10 (25.0%)	
	Unsatisfactory	44 (55.0%)	22 (55.0%)	22 (55.0%)	
Within P‡			<0.001	<0.001	

BCVA: best corrected visual acuity; ET: esotropia; XT: exotropia; pd: prism diopter; SD: Standard deviation, P: Probability, n: number.
 64 children with unilateral and 16 children with bilateral amblyopia contained 96 amblyopic eyes; * Based on Chi-square test; ** Based on MacNemar test; § Based on GEE analysis

for increasing divergence amplitude, therefore they concluded that a short term VT/O could improve vergence amplitude for a long term period and hypothesized that it might relate to better neural control of the visual system[20]. Most of these studies emphasized on satisfactory outcomes of VT/O for convergence insufficiency and intermittent exotropia in youngsters and adult patients. Our study demonstrated significant reduction of the mean angle of esotropic and exotropic deviations in both groups. It means patching is the main factor of amblyopia therapy; therefore it would improve fusion and convert heterotropia to heterophoria in some children.

At initial presentation, 56% of our patients had no stereopsis. These cases were at risk of converting their latent deviation to manifest strabismus that might necessitate surgery. After VT/O, 25% of our children had no stereopsis yet and 75% achieved peripheral or central stereopsis with Worth 4 dot or Titmus tests that might provide a stable sensory and motor status for a longer period.

Although development of stereopsis has been generally reported to happen in early infancy, there are few studies which have shown its development at later ages even up to adulthood. For example in Moriss et al.[23] study 100% and 66% of 12 congenital esotropic patients with late operation (mean age 8 years) who were aligned within±8pd with no amblyopia showed fusion with Worth 4 dot and Titmus tests, respectively. He suggested that some patients might have a period of alignment that the author was not aware of, so there is a possibility of achieving fusion even with late operation and VT/O can help them to obtain fusion faster.

In our study, visual performance (including BCVA, ocular alignment and stereopsis) improved in both groups, but there was no significant difference between them. Some studies have reported more improvement of visual performances among amblyopic patients under VT/O (perceptual vision therapy) compared with those who only achieved patch therapy[24,25]. Lack of difference between our groups might be due to applying patch therapy in both the intervention and control groups, since we ethically did not want to deprive any of our amblyopic children from patching as the main method of amblyopia therapy.

Due to the younger age of our cases (3 to7 years), it was not feasible to measure accommodative and fusional amplitude precisely as well as applying some types of VT/O such as pencil push-ups, therefore we only trained them using prism or synoptophore exercises. A relatively small sample size can also be considered as another limitation for our study.

Conclusion

In conclusion, although VT/O could improve VA as well as sensory and motor status in both groups of 3 to 7 year-old children, only the difference of sensory status (fusion and stereopsis) between them were statistically significant. Further studies in this age range with larger sample sizes focusing on accommodative and fusional amplitude are warranted.

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