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Effect of the EYE-  
PORT® System on  
visual function in  
ADHD children:  
A pilot study



OPTOMETRIC  
EXTENSION  
PROGRAM

# Effect of the EYEPORT® SYSTEM on VISUAL FUNCTION in ADHD CHILDREN A PILOT STUDY

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## Abstract

The diagnosis of ADHD is a complex procedure that includes a subjective evaluation of a person's behavior by parents, teachers and physicians. Many auditory, behavioral and vision conditions can mimic ADHD. Visual function clearly impacts attention, particularly during near point activities such as reading. This study investigated if a type of therapy (EYEPORT®) would significantly improve attention. This system was the sole vision therapy (VT) instrument used in this study. The Test of Variables of Attention (TOVA®) was used to objectively measure visual attention. ADHD-diagnosed subjects were divided into two groups by age. All subjects were examined at baseline, mid-study and completion of therapy, with the TOVA® and with optometric tests. The 1<sup>st</sup> group underwent VT for four weeks while the 2<sup>nd</sup> group did not receive VT. After four weeks, (mid-study) the 2<sup>nd</sup> group received VT and the 1<sup>st</sup> did not. Serious compliance problems were encountered. Significant improvements in the amplitude of accommodation and stereoacuity were found with those that completed the study. The TOVA® variables, commission errors and response time also significantly improved. EYEPORT® therapy administered over a short period of time significantly improved some visual

skills and measures of attention. This pilot study indicated that a more elaborate study should be undertaken to further investigate if VT would show improvement in visual attention of ADHD-diagnosed subjects.

## Key Words

accommodation, Attention Deficit Hyperactivity Disorder (ADHD), binocularity, EYEPORT®, ocular-motor, Test of Visual Attention (TOVA®), visual attention

## INTRODUCTION

Attention Deficit Disorder or Attention Deficit Hyperactivity Disorder (both referred to here as ADHD) is one of the most commonly diagnosed childhood psychiatric conditions.<sup>1</sup> Fifteen million children and approximately eight million adults in the U.S. are diagnosed as having ADHD.<sup>2</sup> Although alternative management options exist, the most common method of treatment is stimulant medication such as Ritalin or Adderall.<sup>3</sup> The diagnosis of ADHD is controversial since the diagnostic criteria are subjective.<sup>1</sup> A minimum protocol for diagnosing ADHD requires: a thorough case history, a sensory screening (visual and hearing) and health examination (physical, neurological, and developmental/neuro-maturational).<sup>4,5</sup> In order to be diagnosed with the condition, a patient must have six of nine symptoms (Table 1) in one of two categories: inattention or hyperactivity/impulsivity.<sup>4</sup> The observable symptoms must be inappropriate for the age of the child, present for six months, present in more than one setting and present before the age of seven.<sup>5-7</sup> Visual attention plays an integral role in ADHD and in near-point visual performance.<sup>8</sup> However, a deficit in

visual attention can also be caused by emotional problems, learning disabilities, and/or environmental influences.<sup>9</sup>

The purpose of the present study was to determine if visual attention of children diagnosed with ADHD, as determined by the Test of Variables of Attention-TOVA®<sup>a,10-14</sup> (TOVA), could be changed by vision therapy (VT). The VT was conducted exclusively with the EYEPORT®<sup>b</sup> (EYEPORT). Several studies have indicated that use of this device can improve selected aspects of visual skills.<sup>15-18</sup>

## Vision Skills and ADHD

Children with ADHD have an inability to selectively process relevant information while effectively ignoring distracting information.<sup>19</sup> They also have problems shifting and sustaining attention, linking new information to old, and controlling motor behavior.<sup>20</sup> In addition, they demonstrate deficiencies in visuo-motor processing, higher level integrative processing<sup>21</sup> and show a significantly greater amount of visual symptoms than do children without ADHD.<sup>5,6</sup> These vision problems include oculomotor, binocular and accommodative responses, visual memory, and/or spatial orientation. Inefficient visual skills can interfere with attention and consequently interfere with executive brain function, reflecting the same symptoms as ADHD.<sup>22,23</sup> ADHD children particularly have less control over saccade accuracy and have slower visual reaction times.<sup>24-27</sup>

VT for visual dysfunction is known to relieve visual symptoms.<sup>1,28</sup> Case studies showed that after VT, some children misdiagnosed with ADHD were allowed, with doctor approval, to discontinue medication.<sup>1</sup> VT techniques were effective in improving pursuits, saccades, fixations,

convergence, accommodation, visual perception and speed of visual processing, in extensive literature reviews.<sup>22, 28</sup>

## TOVA

The computer based TOVA has been used to quantify visual attention.<sup>10</sup> It is not marketed as a stand alone test to diagnose ADHD, but as an ancillary tool for diagnosis along with the standard behavioral history administered when ADHD is suspected. It is a DOS-based,<sup>11</sup> 25.5-minute test that presents geometric stimuli for 100 msec every 2 seconds.<sup>12</sup> Reaction time, vigilance, and the impulsivity of a subject are measured.<sup>13</sup> The subject responds manually to the stimuli.<sup>12</sup> Geometric stimuli were chosen to prevent confounding factors such as language processing skill or short-term memory deficits.

The TOVA test requires a subject to sit with his head approximately 50 centimeters from a computer screen. It incorporates a 2.5-minute practice session prior to testing. A white rectangle is flashed on a black screen every two seconds. The rectangle is approximately 5 x 7 centimeters, depending on the size of the monitor and a 1-centimeter black square appears inside the rectangle. The square is located either at the top or bottom of the rectangle. Subjects are instructed to press a switch when a black square flashes toward the top of the white rectangle and refrain from responding when it is located toward the bottom of the rectangle. The data is transmitted to the TOVA company that analyzes and calculates each of the scores. They are reported in standard scores, compared to age and gender norms (Table 2) according to: response time, variability of response time, commission errors, omission errors, and dPrime, (a calculation of the ability to detect stimuli).<sup>12</sup>

TOVA has two segments. The first presents the target 22.5% of the test time (11.5 minutes) and measures sustained attention. The second part presents the stimulus target 77.5% of the time (11.5 minutes), forcing the subject to inhibit responses and measures impulsivity. Errors of commission and omission, reaction time average for correct positive responses, variability of reaction time, multiple responses, and anticipatory responses are measured for each test segment. A previous study showed that eighty percent of ADHD children were correctly identified using the TOVA when ADHD was defined as being 1.5 standard deviations from age and gender adjusted means.<sup>14</sup>

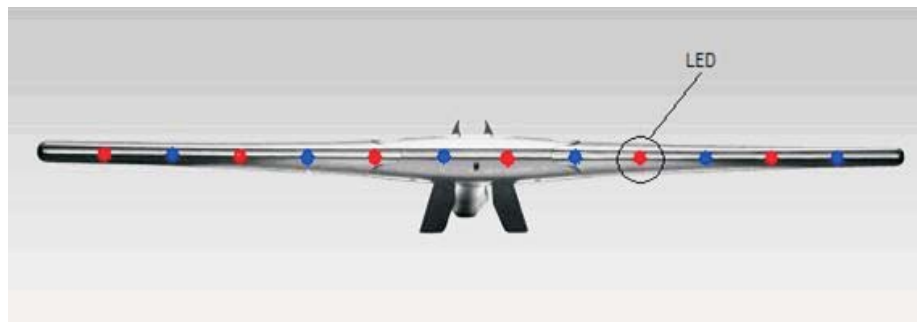


Figure 1. EYEPORTRM. A photograph of the EYEPORTRM Vision Training System manufactured by Exercise Your Eyes, Inc. ([www.exerciseyoureyes.com](http://www.exerciseyoureyes.com)), San Juan Capistrano, CA.

**Table 1. Symptoms of ADHD according to the Fourth Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)<sup>4</sup>**

INATTENTION (ADD)	HYPERACTIVITY/IMPULSIVITY (ADHD)
1) Fails to give close attention to details	1) Often fidgets with hands or feet or squirms in chair
2) Difficulty sustaining attention	2) Often leaves seat when sitting is required
3) Does not seem to listen when spoken to directly	3) Often runs about or climbs excessively in situations where it is inappropriate
4) Does not follow through on instructions	4) Has difficulty playing quietly
5) Has difficulty with organizing tasks and activities	5) Often "on the go"
6) Avoids or dislikes activities which require sustained mental effort	6) Often talks excessively
7) Often loses things	7) Often blurts out answers before question is complete
8) Is easily distracted	8) Often has difficulty waiting turn
9) Often forgetful in daily activities.	9) Often interrupts and intrudes on others.

**Table 2. TOVA Data Points**

Measure	Explanation	Standard Scores
Response Time	Speed of subject's response to a stimulus	RSST
Response Variability	Variability of response time over the test	VSST
Commission Errors	Response made when not appropriate	CSST
Omission Errors	No response made when it was appropriate	OSST
dPrime	The ability to detect the stimulus (A ratio of correct response-hit rate to the false response-false alarm rate; and is a measure of the perceptual efficiency of the subject)	DSST
Test Results	Estimation of presence of ADHD (based on a Standard Score of less than 85) Normal 85-115	TRST

## EYEPORTRM

The EYEPORTRM system (Figure 1) consists of a 36-inch rod with an array of 12 alternating, six red and six blue, light emitting diodes (LEDs) (powered by batteries, or an AC adapter).<sup>15-17</sup> It allows stimulation of each eye independently when canceling lenses are worn. It can be placed in vertical, horizontal and diagonal posi-

tions, including perpendicular to the user for near-far-near stimulation. An auditory feedback option can be programmed to sound each time a light blinks.

The instrument contains three incremental programs, from easy to hard, ten settings for speed and a variable speed setting. The subject sequentially follows illuminated lights with his eyes while wearing spectacles with red/blue filters. The recommended protocol is 10 minutes of

**Table 3. Optometric and TOVA Findings that Statistically Improved With EYEPORT Visual Training System**

OPTOMETRIC FINDINGS			
	Pre VT Scores Mean ± Stand Dev	Post VT Scores Mean ± Stand Dev	Significance p Value
ACCOMMODATIVE AMPLITUDE (cm)			
OD	8.44 ± 3.28	7.75 ± 2.69	.019
OS	8.41 ± 4.80	7.36 ± 4.31	.017
OU	8.29 ± 4.79	6.47 ± 2.22	.020
STEREO (arc sec)			
	103.82 ± 142.69	58.06 ± 87.62	.002
TOVA®			
CSST	107.40 ± 10.91	111.64 ± 8.20	.033
RSST	79.16 ± 30.67	82.80 ± 26.64	.016

**Table 4. Groups Pre-VT Measures**

GROUP 1	GROUP 2	Significance p Value
ACCOMMODATIVE AMPLITUDE-PRE VT		
OD 6.94 ± 2.49	9.29 ± 3.02	.043
OS 6.31 ± 2.53	9.53 ± 5.60	.020
OU 6.14 ± 2.55	8.65 ± 4.44	.043
TOVA		
VSST 92.87 ± 20.51	72.47 ± 22.69	.009
RSST 92.56 ± 18.24	68.61 ± 32.39	.010

training, six days per week, for 12 weeks at home.<sup>15</sup>

Previous work with the EYEPORT has shown improvement in little league base ball batting scores.<sup>16</sup> It has also been used to train police recruits.<sup>17</sup> This study reported significant improvement in visual attention for objects, improved speed and span of recognition and improved marksmanship.<sup>17</sup> In another study, the use of the EYEPORT demonstrated positive improvements in visual performance and in reading skills.<sup>18</sup>

**METHODS**

The project was reviewed and approved by the Northeastern State University (Tahlequah, OK) Institutional Review Board. Potential subjects were selected based on a prior diagnosis of ADHD and subsequent prescription of stimulant medication.

Subjects were recruited through local schools, counseling services, and medical offices. Informational packets were distributed to over 400 ADHD-diagnosed children, eight to 14 years of age. A history questionnaire and the College of Optometrists in Vision Development 30 Item Quality of Life checklist (COVD-QOL)<sup>5</sup>

were completed on 24 subjects who volunteered for the study.

Baseline optometric testing included:

- 1) monocular and binocular visual acuity
- 2) extraocular motility testing
- 3) pupil reactions
- 4) distance and near cover test
- 5) near point of convergence
- 6) accommodative amplitude
- 7) NSUCO Saccades and Pursuits Test<sup>c,29-33</sup>
- 8) Randot (Wirt Circles)<sup>d</sup> stereoacuity
- 9) Nott retinoscopy
- 10) direct ophthalmoscopy
- 11) completion of the COVD-QOL
- 12) visuoscopy {evaluated the type (central/eccentric) & stability (steady/unsteady) of the fixation}.

**STUDY DESIGN**

We divided our subjects into a younger group (Group 1: 7.5 to 10 years of age) and an older group (Group 2: 10.5 to 14.5 years of age). Each subject was administered the optometric tests and the TOVA at the start, the midpoint and the completion of the project. The protocol was similar to that of Lieberman and Horth.<sup>16</sup> The parents/guardians and subjects of Group 1 were initially trained in the use of the EYEPORT. The EYEPORT orientation and training was administered individu-

ally by two researchers (HH & KM). The parent/guardian and the subject were shown how to use the EYEPORT. They were then required to demonstrate a proficiency in the use of the instrument before it was dispensed. They were instructed to use the EYEPORT as directed for 10 minutes a day, five days/week for four weeks. The parent/guardians were periodically contacted during the project to insure therapy compliance and to address identified problems.

All subjects continued with medication dosage schedule as prescribed by their medical doctor. Group 1 trained at home for the first four weeks while Group 2 continued their daily routine. After week four, each subject was retested with both the optometric tests and the TOVA. Group 1 then returned their EYEPORTs and Group 2 parent/guardian and subjects were thoroughly trained, as before, in the use of the EYEPORT before dispensing the instrument. The same protocol for Group 2 was then followed, as was Group 1 previously. At the end of week eight, all participating subjects returned for final testing.

Parametric analysis (t-tests, ANOVA, and Pearson product-moment correlations) was performed on data that included TOVA Standard Scores, visual acuity, nearpoint of convergence, amplitude of accommodation, stereo vision, and Nott retinoscopy. Non-parametric data (saccades and pursuits) were analyzed with the Wilcoxon Signed-Rank test and Spearman's Rho correlation. Statistical analysis was performed on the total group, comparing pre-EYEPORT therapy data to post-EYEPORT therapy data. An analysis was also performed between the two groups. A p-value equal to or less than 0.05 was considered statistically significant.

**RESULTS**

Twenty four ADHD-diagnosed subjects (19 males, five females) completed baseline exams but only 17 completed the study. All subjects were taking ADHD medications at the start of the study but four subjects discontinued use of their medications for the summer, with their doctor's direction. TOVA test scores for four subjects were lost during transmission to the company for analysis leaving complete data for only 13 subjects. The loss of 11 subjects, (seven discontinued the project; four were lost in transmission) precluded a post therapy analysis between the groups.

The mean accommodative amplitude improved significantly from a pre-treatment mean of  $8.29 \pm 4.79$  cm to  $6.47 \pm 2.22$  cm post-treatment. Stereo acuity also improved significantly (post-treatment to  $58.06 \pm 87.62$  arc sec from  $103.82 \pm 142.69$  arc sec [Table 3]). The mean Standard Score of Commission Errors (CSST) and the mean Standard Score of Response Time (RSST) also showed significant positive changes following EYEPORTherapy. [(CSST  $107.40 \pm 10.91$  to  $111.64 \pm 8.20$ ); (RSST  $79.16 \pm 30.69$  to  $82.80 \pm 26.24$ )]

Other optometric findings showed improvement (COVID 30-item checklist, visual acuity and nearpoint of convergence) but none were statistically significant. Eight of 17 subjects noted symptom improvement on the COVID 30-item checklist. Five of eight subjects who initially exhibited monocular uncorrected visual acuity worse than 20/20 improved two lines or more and three of these showed improved visual acuity in both eyes. Ten subjects numerically improved their nearpoint of convergence measures. Twelve subjects exhibited abnormal fixation as shown by Visuoscopy testing before training but only three showed abnormal fixation post-therapeutically. The TOVA mean standard scores for response variability (VSST), omission errors (OSST) and dPrime (DSST) showed numerical improvement as well, but did not reach statistical significance.

We compared the pre-therapy scores by age and found that Group 1 (7.5 to 10 yrs) performed better than Group 2 (10.5 to 14.5 yrs) on pre-VT accommodative amplitude monocularly (OD,  $p=.043$ ; OS,  $p=.020$ ) and binocularly ( $p=.043$ ) and the younger group's standard score also showed better performance on pre testing with the TOVA RSST ( $p=.010$ ) and VSST ( $p=.009$  [Table 4]).

## DISCUSSION

Accommodative amplitude and stereo acuity of the groups improved significantly, post therapy. Other visual skills also showed measured, but insignificant improvement, including the COVID 30-item checklist, visual acuity and the near point of convergence. The CSST and RSST TOVA standard scores improved significantly after EYEPORTherapy, indicating improvement in both attention and impulsivity.

There are a number of factors that require this study to be considered a pilot study.

These factors include the limited therapy that each subject received, the limited number of subjects that completed the study and the poor compliance to the therapy regimen by some subjects.

The duration of therapy was only four weeks and 200 actual EYEPORTherapy training minutes. The manufacturer's recommended therapy time is 12 weeks and 720 actual minutes of EYEPORTherapy training.<sup>15</sup> The subjects in this study received only 28% of the recommended EYEPORTherapy time. Two previous studies with adult samples<sup>17,18</sup> and one with children<sup>16</sup> were trained for a shorter time than our study. (10 minutes/day; six days/week for three weeks). All three of these studies demonstrated improvements in motor performance, vision skills and attentional skills. The present sample of ADHD, however, cannot be directly compared to these non ADHD samples.

Would a full course of EYEPORTherapy show more significant improvements in the visual skills measures of these ADHD children? A previous study gave ADHD children supervised, in office VT lasting from nine to 13 weeks.<sup>1</sup> These subjects continued VT up to a total of 20 weeks for maximum benefit. A longer period of therapy in this study may well have produced more significant changes.

Seven of our subjects dropped out of the study and four of the remaining subjects' data was inadvertently lost in the electronic transmission of the TOVA results to the TOVA office. These data were unrecoverable. This left only 13 subjects with pre and post TOVA results to be analyzed, forcing us to consider this as a pilot study.

Limited compliance by some of the subjects and their families was a problem. Compliance was highly variable and seemed to be associated with family functionality. While some subjects had supportive families, the majority did not. Subjects who showed the greatest subjective improvement had supportive, involved parents. Many parents voiced concern but seemed to lack the discipline or ability to help their child follow through with the therapy and to keep appointments. In several cases, we contacted subjects several times before we were able to obtain post-training data and retrieve EYEPORTherapy systems.

Traits of the parents may explain some of the lack of compliance. Twenty-five percent of children with ADHD are reported to have a first degree relative with

ADHD.<sup>20</sup> Parental mood and conduct disorders, learning disabilities, and antisocial behavior are also risk factors for ADHD. ADHD is also diagnosed more often in children who are minority group members and/or in lower socio-economic groups.<sup>26</sup> Factors that mimicked ADHD behaviors were evident in the parents/guardians of many subjects in our study. Recruitment was very difficult. Many families appeared to be completely overwhelmed with frantic schedules. More than half of the mothers of our subjects were overwrought with daily tasks and clearly were barely able to manage. One stated that she did not have time to commit to supervising her child for 10 minutes a day of training.

The majority of parents would report no compliance problems when we contacted them by telephone but then would admit noncompliance face to face at the exam. Dealing with the schedule was so difficult that some parents stopped responding to the phone calls and would not keep scheduled examinations despite efforts to visit them outside the clinic setting. In one case we had to go to a residence to retrieve the EYEPORTherapy system. In another instance, on the day of the final examination, a subject came to her appointment and said she was unable to continue because she had not trained and her mother would not come into the clinic. We concluded that many of the problems facing these children can not be solved by giving them medication or the best VT program. At the end of the day, they still go home to an environment that may have initiated part of their problematic behavior.

The contrast between the parents of children who dropped out of the study and the parents of the children who finished was dramatic. The parents of the subjects who finished the study represent an environment in which VT can be most effective. With family support and involvement, consistent discipline, regular meals, and good sleep schedules, children are much more likely to succeed in any endeavor.

Finally, we found statistically significant differences between the age groups. Accommodative amplitude is expected to decrease with age and our data confirmed that the younger group measured a higher accommodative amplitude. The TOVA findings are expected to improve with increased age and increased maturation of the subjects.<sup>10</sup> The results of our study show an opposite trend. The younger group measured statistically better

improvement than the older group. Could this indicate that the earlier an ADHD child is treated for visual conditions, the more improvement might be expected? More studies with a larger sample size, a longer duration of therapy and particularly, better subject selection and compliance could help to answer if EYEPORTherapy is beneficial in the treatment of ADHD and if earlier treatment is better.

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