RESEARCH

The Effect of Optometric Vision Therapy for Individuals on the Autism Spectrum, Part 1: Balance, Visual Perception, Reading Ability, and Peripheral Visuomotor Coordination

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ABSTRACT

Background

Autism Spectrum Disorder (ASD) is one of the most prevalent disorders in modern societies. The prevalence highlights its rapid growth and the profound impact it has on the lives of millions of people worldwide.

Although a multidisciplinary approach is required to address this phenomenon, the research presented here focuses exclusively on the effect of optometric therapy/training in individuals on autistic spectrum. This study aims to identify and examine the potential benefits on sensory processing, visual perception, and academic performance that individuals affiliated with ASD may derive from optometric vision training.

Materials and Methods

Fourteen participants were divided in two groups of seven individuals. The first group underwent an optometric therapy/training for a period of seven months, while the second group served as a control group with no therapy received.

Results

The quantitative findings indicate significant improvement in factors like static balance, visual perception, reading ability, and peripheral oculomotor response. There are also qualitative remarks on psychological disposition, intra-family communication, long-term memory, maturation in speech and vocal tone, improved academic performance, and engagement in extracurricular activities requiring specific skills (e.g., sports, dance, painting).

Conclusions

Optometric therapy/training serves a valuable tool in enhancing not only visual function but also overall behavior of individuals on the autism spectrum, on both the sensory and perceptual levels.

Additionally, noteworthy changes were observed in the social, academic, and psychological behavior of the participants.

1.0 INTRODUCTION

Individuals with Autism Spectrum Disorder (ASD) frequently present with differences in sensory processing that influence multiple aspects of daily functioning, including motor coordination, visual perception, and academic performance. Research has shown that visual processing difficulties are common in this population and may contribute to challenges in tasks requiring integration of visual and motor information.[1-11]

Efficient visual processing plays an important role in postural control, spatial orientation, and reading performance.[12,13] The visual system interacts closely with vestibular and proprioceptive systems in maintaining balance and coordinating body movements. When visual input is inefficient or poorly integrated, individuals may experience difficulties with visual perception, peripheral awareness, and visuomotor coordination, which can affect both motor development and learning processes.[14]

Optometric vision therapy has been proposed as a non-invasive intervention aimed at improving visual processing and visual-motor integration through structured and individualized training programs. By targeting visual skills such as tracking, spatial awareness, and peripheral processing, vision therapy may contribute not only to improvements in visual performance but also to broader functional abilities.[15,16,17]

The present study investigates the effects of optometric vision therapy on individuals with ASD in areas related to balance, visual perception, reading ability, and peripheral visuo-motor coordination, with the aim of exploring the potential functional benefits of this intervention.

2.0 METHODS

2.1 Study Design and Participants

Two groups of seven participants each were selected for this prospective study. Group A consisted of individuals on the autism spectrum who received vision therapy for 7 months, while Group B served as a control group, receiving no intervention. Both groups underwent baseline assessments using standardized tests administered by an optometrist, and were re-evaluated on the same tests after a period of 7 months.

The standardized assessment tests involving the functions in this study, namely balance, visual perception, reading ability, and peripheral visuomotor coordination are detailed in Section 3.0. A companion paper provides the assessment tests and results for other visual functions in the same population including near point of convergence, accommodation flexibility, vergence flexibility, oculomotor function, and stereopsis.[34]

Participants in Group A attended the training facility 2 times per week and completed vision exercises administered by a certified optometrist. The duration of each session was 90 minutes, consisting of 20 minutes of syntonic phototherapy, 60 minutes of optometric vision therapy, and 10 minutes of social interaction with the participant and parents. During the intervention period, both groups continued with the supportive ASD services that were being provided at the outset of the study.

Participants in Group B were only required to return for re-assessment after 7 months, with no vision therapy provided during this period.

Table 1: Age and mean age of participants and control group.

PARTICIPANTS								
PERSON	1	2	3	4	5	6	7	MEAN AGE
AGE	7	13	8	7	7	12	9	9.0
CONTROL GROUP								
PERSON	1	2	3	4	5	6	7	MEAN
AGE	11	12	9	11	12	13	8	10.8

Eligibility was determined based on verbal ability and age (5-14 years). Participant assignment to each group was done by randomization.

2.2 Procedure

Each participant was assessed in 4 domains: static balance, visual perception, reading speed, and peripheral optokinetic response. A therapy program was individualized for each of the seven participants in Group A based on the relative weaknesses exhibited in the assessment tests described below, consistent with optometric therapy procedures applied to the ASD population.[15,17] The therapy was entirely office-based, as no home therapy procedures were assigned. An overview of therapy procedures in provided in Appendix A.

Parents were responsible for transporting participants to the training facility 2 times per week to ensure adherence to the program. After 7 months, participants were re-assessed in the same domains using identical tests.

3.0 ASSESSMENT TESTS

3.1 Assessment of Static Balance Function

In order to evaluate potential improvements in overall body functions, quantitative assessments were conducted. A critical factor for human existence, beyond basic physiological functions, is the ability to maintain balance against gravity—requiring control and coordination of all body segments. Insufficient or demanding balance compromises both survival and cognitive development and as a higher-order brain processing, depends on optimal postural control.

Accordingly, the primary aim of the assessment was to evaluate the balance systems—vestibular, visual, and proprioceptive—and their integration. The study employed Balance Tracking Systems (BTS) software,[18,19,20,21] which allows the measurement of participants' likelihood of balance loss and comparison with a global database of age- and gender- matched normative performance.

The BTS software records the displacement (in cm) of the foot's support point over a 20-second period, and the test is conducted under four different conditions. Greater displacement indicates reduced static balance.

Figure 1. Balance Tracking Systems software and hardware for balance assessment

The software processes participants' personal data and test results to provide a percentile ranking based on the system's global database of age- and gender-matched individuals. For instance, a 5th percentile ranking indicates that the participant performed better than only 5 out of 100 peers, highlighting a significant deficit relative to expected norms and an increased risk of balance loss and injury.

Normative values, as defined within the BTS database, are presented in the following tables for reference.

3.2 Reading Assessments

The Thomson Eye Tracker software (Figure 2) was used in this study to record the operation of the visual system during reading. Correct operation of the program required hardware, including a laptop computer and a 22 inch screen. Located at the lower portion of the screen, the "Tobii Pro" device was applied to detect eye movements.

The operating interface of the Thomson Eye Tracker enables the integration of any Microsoft Word document. This makes the system compatible with any language. The integration feature also provides the ability to zoom the text according to the needs and requirements of the exam. For this

Table 2: Age and gender-specific data for foot support center displacement

BTrackS mCTSIB Norms (Ages 5-9 years)

	Standard		Proprioception		Vision		Vestibular		Composite	
%ile	M	F	M	F	M	F	M	F	M	F
100%	13	12	20	17	14	17	28	30	94	91
90%	17	16	26	23	23	21	46	44	132	116
80%	20	19	31	27	26	24	52	48	140	130
70%	22	21	34	30	29	27	57	53	153	138
60%	25	23	37	32	33	29	62	59	162	149
50%	27	24	39	33	35	33	67	63	172	155
40%	30	27	43	38	39	37	73	65	183	169
30%	34	29	48	42	44	40	79	71	203	181
25%	36	32	50	44	46	42	81	78	212	188
20%	37	32	54	46	49	45	85	80	217	193
10%	45	41	60	59	59	55	103	91	262	236
1%	95	98	132	74	138	84	173	141	450	327

BTrackS mCTSIB Norms (Ages 10-14 years)

	Standard		Proprioception		Vision		Vestibular		Composite	
%ile	M	F	M	F	M	F	M	F	M	F
100%	10	9	10	16	15	12	32	31	72	74
90%	14	13	20	18	18	18	38	38	99	97
80%	16	15	23	22	20	19	42	43	106	107
70%	17	16	25	24	23	22	46	45	115	114
60%	20	17	27	26	26	24	50	47	126	119
50%	23	19	28	28	27	25	54	52	142	129
40%	26	21	34	31	29	26	61	57	153	138
30%	31	23	39	34	34	29	66	64	167	146
25%	32	24	39	35	35	30	67	66	170	149
20%	36	24	40	36	39	31	69	67	179	153
10%	41	26	55	38	44	38	81	78	196	164
1%	56	33	61	82	62	49	111	147	250	292

test, letters were standardized to the same size as grade level reading books. Text size was calibrated for the viewing distance of 45-65cm.

The Thomson Eye Tracker program also provided the ability to display monocular or binocular motion. It was used to record reading speed, the number of eye fixations to read the text, the number of regressions per line (rereading or looking back), and horizontal and vertical vergences.

In addition, information related to head tilt when reading, blink rate, and inter pupillary distance were recorded, as well. Thomson Eye Tracker software (Figure 2) was used to record the operation of the visual system during reading. The Tobii Pro device provided the ability of the program to detect eye movements.

Before recording the eye movements, a calibration was performed to identify the movements of each eye with great accuracy. The following instruction set was then given to the examinee: "A text will appear on the screen. I would like you to read it as clearly and quickly as you can." The text that the examinee was asked to read consisted of 16 lines. Each row contained exactly 10 words.

The recording started from the second paragraph and continued for the next 50-70sec, with the first paragraph used as an adaptation to the reading conditions for all tested students. The examiner stopped recording when the child had finished a series of readings within the time frame mentioned above.

Figure 2. Software and hardware by Thomson Eye Tracker for evaluation of reading speed.

What was recorded were the reading speed in words per minute (wpm), the average number of fixations per line (fix/ line), and the average number of regressions per line (reg/line).[22,23,24]

3.3 Assessment of Peripheral Visual-Motor Response Coordination

Peripheral visual input alone is insufficient for effective functional performance; appropriate motor responses are required to enable the body to react consciously, either cognitively or physically. To assess this coordination, a peripheral vision-motor response test was included in the study.

The test utilized six peripheral touch targets (Fit Light), which were activated sequentially at 1-second intervals. Participants were instructed to touch each illuminated target within a one-minute period as it became active.[25]

Figure 3. Fit Light targets for evaluation of Peripheral Visual-Motor Response Coordination

3.4 ASSESSMENT OF VISUAL PERCEPTION (TVPS 4)

Visual perception determines the interpretation and response to the visual stimuli received by each individual. It is essential to be able to perceive, analyze, interpret, and decide how to respond—either cognitively or through action—to the visual stimulus.

For the purposes of the research and the assessment of visual skills, the TVPS-4 test[26,27,28] was used, which includes the evaluation of participants in the following seven visual perception skills.

3.4.1 Visual Form Recognition/Discrimination

Visual form recognition/discrimination skill helps identification of small differences between similar visual stimuli. Possessing this ability allows us to recognize differences between letters, words or objects that appear very similar among others.

3.4.2 Visual Memory

Visual memory refers to the ability to easily recall characteristics of visual stimuli that are present within our visual field.

3.4.3 Visual Form Constancy

Visual form constancy is the ability to recognize and understand a visual stimulus even when it is not presented in the same form or size as previously encountered.

3.4.4 Visual Sequential Memory

Visual sequential memory refers to the ability to remember symbols or characters in the order in which they appear. This skill is important for recognizing words and shapes, for reading, and for remembering telephone numbers, and other similar useful information.

3.4.5 Visual Spatial Relationships

Visual spatial relationship refers to the ability to recognize different forms of objects, their position in space, and their relative position to one another. It includes the ability to reproduce a symbol or an object. This skill is particularly helpful when attempting to create a mental image of a lost object or when forming a mental representation of an image from a word read in a text.

3.4.6 Visual Figure–Ground

Without the visual figure–ground skill, a child is unable to locate and focus on a specific detail of interest within a larger set of visual information that may not be relevant at that moment. As a result, the child may have difficulty identifying a word within a text or locating an operation within a mathematical expression.

3.4.7 Visual Closure

Visual closure refers to the ability to perceive a complete image when the available visual information is incomplete. This skill allows individuals to read a text quickly without the need to examine every letter of a word in order to understand its meaning.

4.0 RESULTS

4.1 Static Balance

The participants' performance was determined by the displacement of the foot support point during a time period of 20 seconds under four (4) different conditions.

Table 3 presents the mean (M) and standard deviation (SD) of the total displacement of the foot's center of support, during the assessment of the three balance systems at the initial and final measurements for each group. Repeated measures of ANOVA were conducted in order to evaluate the change in participants' static balance as well as to investigate the effect of the group.

According to the results presented in Table 4, a statistically significant interaction between time and group was observed ($F_{1,12} = 28.51$, $p < 0.001$). More specifically, the post-hoc comparisons showed a statistically significant reduction in the total displacement, indicating improved static balance, in Group A, pictured next page, (310.57 ± 96.93 vs 151.57 ± 47.97, $p < 0.001$). In contrast, no significant improvement was found in Group B , pictured next page, (332.43 ± 114.34 vs 329.29 ± 108.04, $p = 0.882$) (Diagram 1).

Table 3: Mean (M) and standard deviation (SD) of the total displacement of the foot's center of support during the assessment for static balance

	N	Baseline Measurement	Final Measurement
Group A	7	310.57±96.93	151.57±47.97
Group B (control)	7	332.43±114.34	329.29±108.04

Table 4: Results of the repeated measures ANOVA for the balance test between the two time points per group

	SS	df	MS	F	p
Time	46008.04	1	46008.04	30.86	<0.001
Time and Group	42510.04	1	42510.04	28.51	<0.001
Group	69700.32	1	69700.32	4.17	0.064

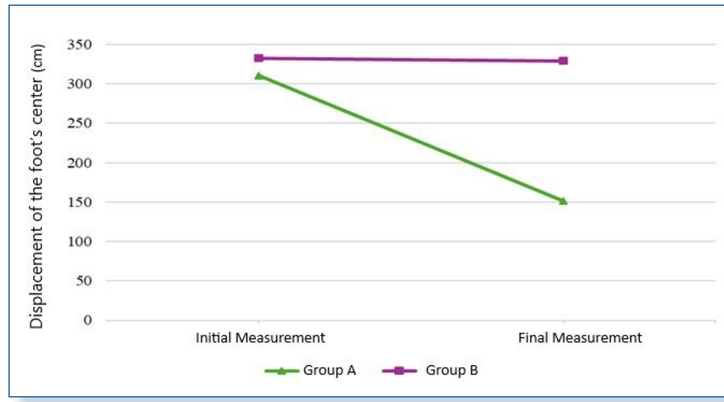

Diagram 1. Change in static balance for each group

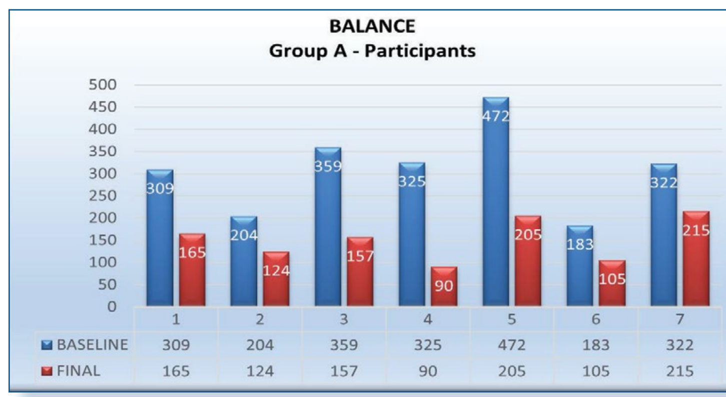

Chart 1. Group A (Participants) - Displacement of foot support (cm)

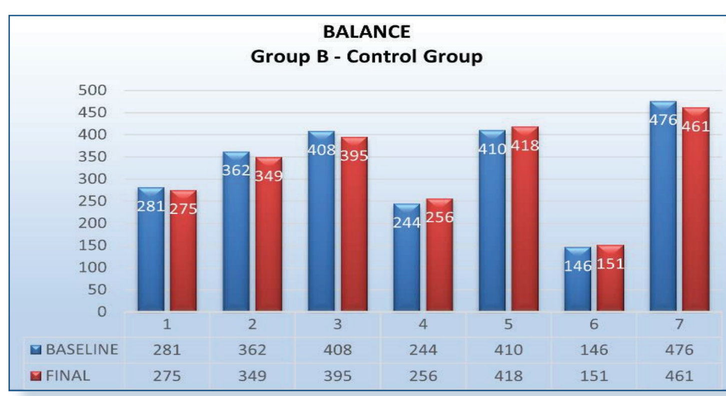

Chart 2. Group B (Control Group) - Displacement of foot support (cm)

4.2 Reading Speed

Reading speed was measured using the Thomson Eye Tracker software through texts that were identical in both the initial and the final assessment and were directly related to the age of each participant.

Table 5 presents the mean (M) and standard deviation (SD) of reading speed at the baseline and final measurements for each group. Repeated measures of ANOVA were conducted in order to evaluate the change in reading speed as well as to investigate the effect of the group. According to the results presented in Table 6, a statistically significant interaction between time and group was detected ($F_{1,12} = 14.05$, $p = 0.003$).

More specifically, the post-hoc comparisons showed a statistically significant increase in reading speed, indicating improved performance, in Group A (33.14 ± 43.32 vs 67.86 ± 41.31, $p < 0.001$). In contrast, no significant improvement was observed in Group B (51.43 ± 40.37 vs 54.43 ± 39.33, $p = 0.625$) (Diagram 2).

Table 5: Mean deviation of baseline and final measurement of reading speed per group

	N	Baseline Measurement	Final Measurement
Group A	7	33.14±43.32	67.86±41.31
Group B (control)	7	51.43±40.37	54.43±39.33

Table 6: Results of the repeated measures ANOVA for the reading speed test between the two time points per group.

	SS	df	MS	F	p
Time	2489.14	1	2489.14	19.86	0.001
Time and Group	1760.14	1	1760.14	14.05	0.003
Group	41.29	1	41.29	0.01	0.912

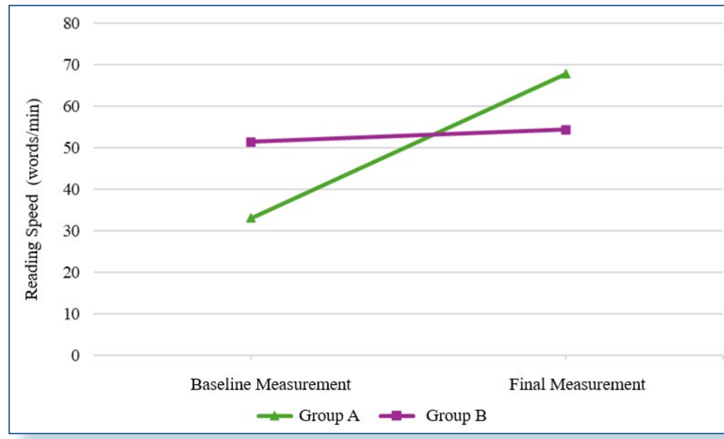

Diagram 2. Changes in reading speed within each group

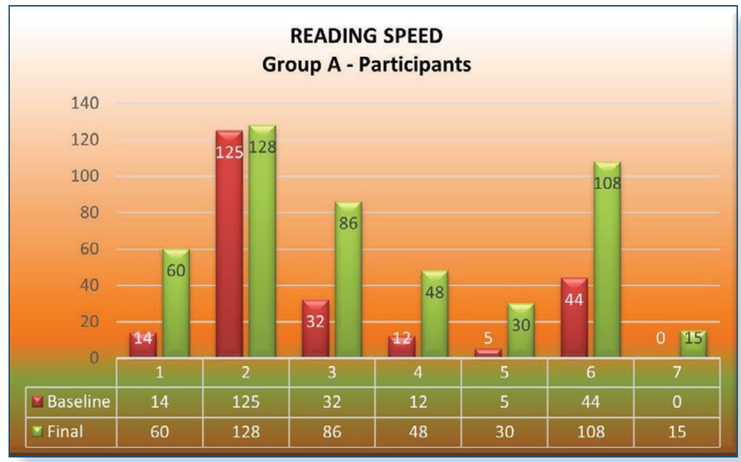

Chart 3. Group A (Participants) — Reading Speed

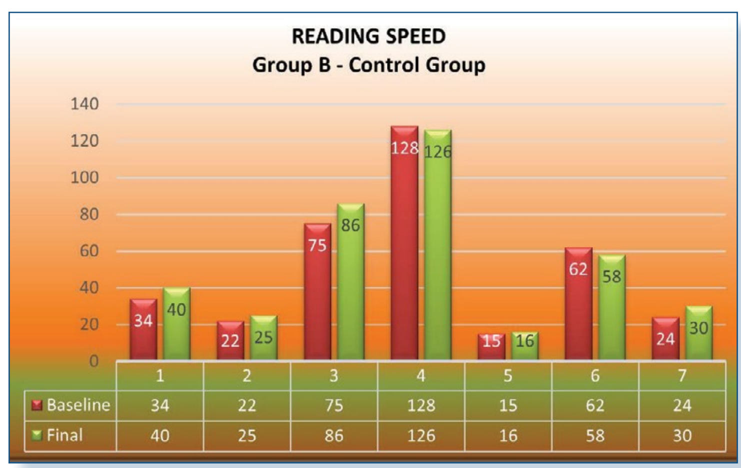

Chart 4. Control Group B — Reading Speed

4.3 PERIPHERAL VISION-MOTOR RESPONSE COORDINATION

Table 7 shows the mean (M) and standard deviation (SD) of peripheral targets that participants were able to locate and touch within 60 seconds during the initial and final assessments for each group. Repeated-measures of ANOVA were conducted to examine changes in participants' performance on peripheral targets and to assess the effect of each group. As presented in Table 8, a significant interaction between time and group was detected ($F1,12 = 48.94$, $p < 0.001$). Post-hoc analyses revealed a significant improvement in the number of peripheral targets located and touched within 60 seconds in Group A (9.57 ± 10.56 vs. 27.57 ± 10.6, $p < 0.001$), indicating enhanced performance. In contrast, Group B showed no significant improvement (14.14 ± 6.07 vs. 15.14 ± 7.67, p = 0.571) (Diagram 3).

Table 7: Mean (standard deviation) for the initial and final measurements of peripheral targets that participants were able to locate and touch within 60 seconds, by group

	N	Baseline Measurement	Final Measurement
Group A	7	9.57±10.56	27.57±10.6
Group B	7	14.14±6.07	15.14±7.67

Table 8: Repeated-measures ANOVA results for the test of peripheral targets that participants were able to locate and touch within 60 seconds, comparing the two time points

	SS	df	MS	F	p
Time	631.75	1	631.75	61.14	<0.001
Time and Group	505.75	1	505.75	48.94	<0.001
Group	108.04	1	108.04	0.72	0.412

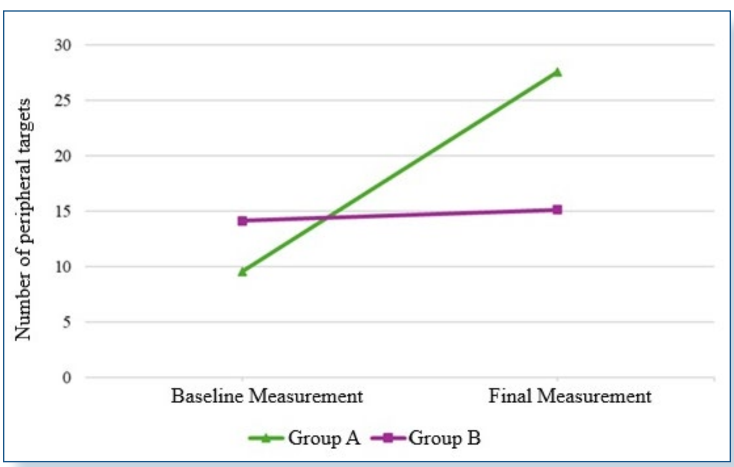

Diagram 3. Changes in the peripheral targets that participants were able to locate and touch within 60 seconds in each group

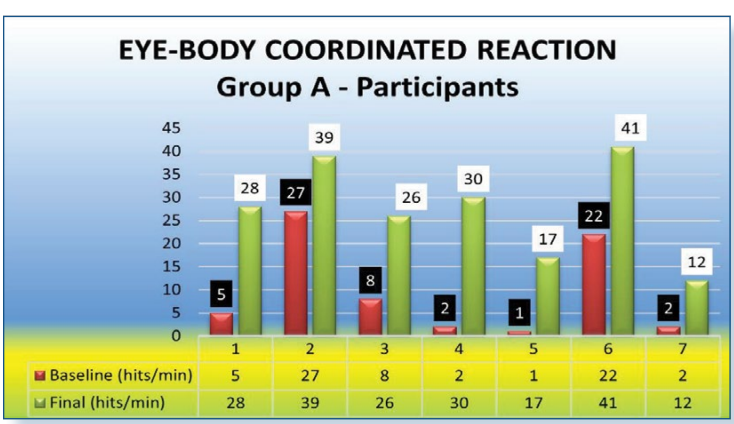

Chart 5. Group A (Participants) — Peripheral Vision—Optokinetic Response Coordination

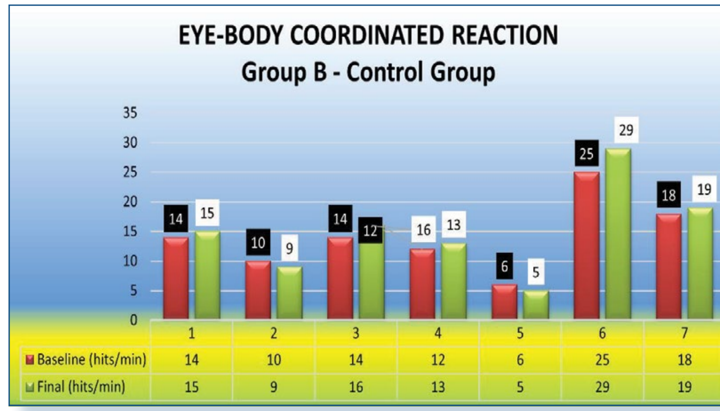

Chart 6. Group B (Control) — Peripheral Vision—Optokinetic Response Coordination

4.4 VISUAL PERCEPTION (TVPS 4)

Participants' performance was assessed based on their responses across the seven subtests of the TVPS. The total number of correct responses was summed, and scores were compared to age-based norms to evaluate performance relative to peers.

Table 9 presents the mean (M) and standard deviation (SD) of visual perception scores during the initial and final assessments for each group. Repeated-measures of ANOVA were conducted to examine changes in visual perception and to assess the effect of group. As shown in Table 10, a significant interaction between time and group was observed ($F_{1,12} = 45.80$, $p < 0.001$). Post-hoc analyses revealed a significant improvement in visual perception in Group A (81 ± 13.06 vs. 97.29 ± 14.16, p < 0.001), indicating enhanced performance, whereas no significant improvement was detected in Group B (81.14 ± 12.12 vs. 82.29 ± 11.97, p = 0.484) (Diagram 4).

Table 9: Mean (standard deviation) for the initial and final measurements of visual perception, by group

	N	Baseline Measurement	Final Measurement
Group A	7	81±13.06	97.29±14.16
Group B	7	81.14±12.12	82.29±11.97

Table 10: Repeated-measures ANOVA results for the visual perception test between the two time points, by group

	SS	df	MS	F	p
Time	531.57	1	531.57	60.67	<0.001
Time and Group	401.29	1	401.29	45.80	<0.001
Group	386.29	1	386.29	1.20	0.295

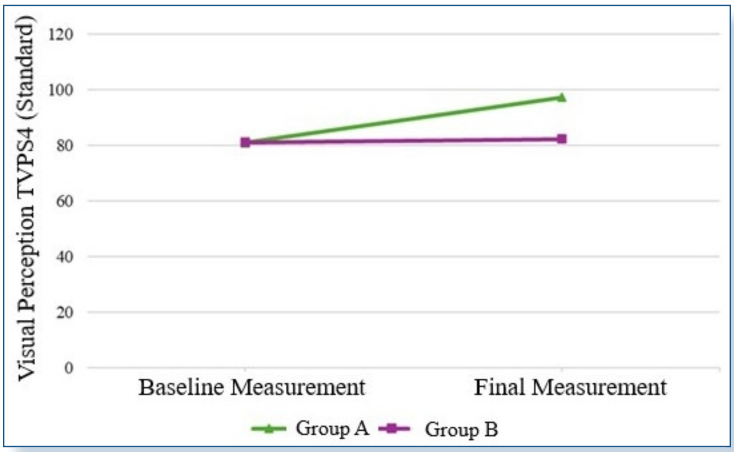

Diagram 4. Changes in visual perception in each group

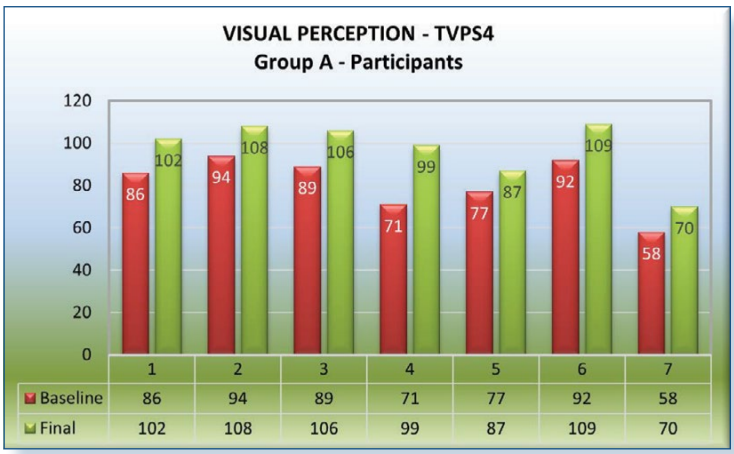

Chart 7. Group A (Participants) — TVPS4 Total Score

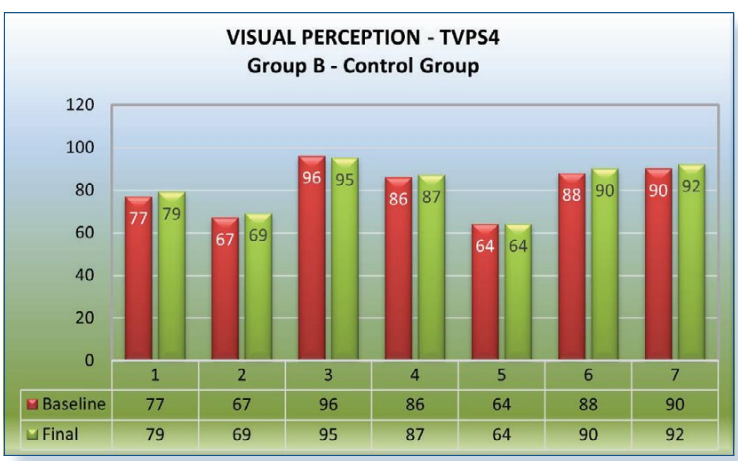

Chart 8. Group B (Control) — TVPS4 Total Score

5.0 DISCUSSION

The quantitative results of this study support several important outcomes. Improvement in static balance and the coordination of balance systems (proprioception, vestibular, vision) was significant in the trained participants, whereas individuals in the control group showed little to no improvement. A significant increase in reading speed was observed in the trained group compared to the control group. Visual perception in the trained group (Group A) showed a striking increase across all examined domains, while the control group did not exhibit notable changes. In the domain of peripheral perception-motor response, the trained participants (Group A) demonstrated significant improvement compared to the control group.

A number of significant changes were also observed that were not quantified but were reported by the parents and therefore deserve mention. These changes can be summarized as follows:

- A noticeable change in the psychological disposition of the trained participants was observed. They began to display a less defensive attitude toward new stimuli and showed no aggressive reactions to them.
- Parents reported significant improvements in intra-family communication and understanding
- Their social interactions improved considerably.
- A significant improvement in long-term memory was observed, as participants became able to recount past events in detail.
- In some cases, maturation in speech and vocal tone was observed.
- Many participants improved their academic performance, according to both teachers' reports and school grades.
- Several participants sought to engage in extracurricular activities requiring specific skills (e.g., sports, dance, painting).
- A better balance among sensory inputs was observed, as many participants had previously relied excessively on one sensory modality at the expense of others.

The above findings are consistent with previous studies reporting atypical patterns of visual processing in individuals with Autism Spectrum Disorder (ASD). Specifically, a differentiated distribution of visual attention and enhanced processing of local visual features at the expense of global perception have been described, as explained by the Weak Central Coherence theory.[29,30]

There are some limitations to the present study. All participants needed to possess sufficient verbal abilities to understand and follow basic instructions; therefore, the potential outcomes for non-verbal individuals could not be evaluated within the scope of this study.

Furthermore, the participants included in the study were classified as medium- to high-functioning on the autism spectrum. As a result, the findings cannot necessarily be generalized to low-functioning individuals, whose responses to the intervention may differ. Another limitation concerns the duration of the training program, which lasted approximately seven to eight months. This period may be considered relatively short for the intervention to be regarded as fully completed for each participant.

As indicated in Section 2.2 (Procedure) the choice of therapy procedures for the experimental group was individualized based on results of the assessment tests, as detailed in Section 3.0. This includes the application of syntonics (optometric phototherapy) for which functional visual fields were conducted but not included in the study. While this is indicative of how therapy is conducted in many optometric practices, using the results of each therapy session for feedback and guidance on what is designed and conducted, it does not readily lend itself to a specific research protocol, particularly for this population. Our principal goal here was to establish that these functions could effectively be trained, rather than to suggest a specific protocol. It is also why, given the nature of the population, 10 minute "socialization" periods were built into each 90 minute sessions to enable the session to be purposeful. We acknowledge that future research might endeavor to develop more specific protocols for this population, and to study the optimal time frame for therapy sessions.

Although this study was prospective, the examiners were not masked. Nor was there a placebo group. The control group was a cohort of patients with ASD who did not receive any therapeutic intervention. Our principal purpose was to establish that the functions studied could be improved with targeted therapy in this population. Future studies should include masking of the examiners and a sham therapy group to account for a placebo effect. Admittedly, it is very difficult to design placebo therapy for a study of this nature.

The age range of the participants, between 5 and 14 years old, also limits the generalizability of the findings, as the study does not provide evidence that similar outcomes would be achieved in younger children or older individuals. Finally, the technological equipment and assessment procedures were administered according to specific protocols established by the supervising optometrist. Consequently, variations in testing conditions or procedures may have resulted in slightly different outcomes.

6.0 CONCLUSIONS

The results of this pilot study indicate that children with Autism Spectrum Disorder (ASD) who participated in an optometric therapy program showed improvement in key developmental and academic aspects guided by visual functions compared with the control group. At the same time, positive changes were observed in indicators of attention, school participation, and behavior, suggesting that targeted optometric intervention may have a beneficial impact on this population.

The improvement in visual functions may be interpreted in light of the role of vision as a central mechanism of sensory integration and neurocognitive processing.[32,33] Children with ASD have been reported to experience difficulties in areas such as oculomotor control, convergence, and visual processing, which may increase cognitive load and negatively affect attention, learning, and behavior. Strengthening these skills through optometric therapy may reduce visual fatigue and facilitate more efficient processing of visual stimuli.[31,32]

In a companion paper in this journal, we report on the effects of optometric vision therapy on the same population as this study, as it pertains to oculomotor ability and accuracy, accommodative flexibility, convergence flexibility, near point of convergence, and stereoscopic acuity.[34]

Future research could investigate the long-term effects of optometric therapy, as well as its combined application with other therapeutic interventions, in order to evaluate its overall role within the framework of interdisciplinary support for children with Autism Spectrum Disorder (ASD).

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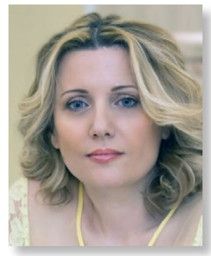

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Melinda Bollano graduated from UNIWA (University of West Attica) in 2000. She received her MSc degree in 2019 and now she is on her way to get her PhD degree.

She is the director of BL Vision Therapy Institute.

Melinda is devoted in vision therapy trying to help people with severe binocular functional problems. Frequently co-operates with occupational and speech language therapists, chiropractors, psychologists and special education teachers in order to provide ideal services for her patients.

Melinda gives lectures to parents, teachers and professionals trying to help them understand how vision works and in which way vision therapy could possibly help children override their vision problems.

When she is not working, Melinda enjoys reading and spending time with her husband and their two children.

APPENDIX A

FUNCTION	SAMPLE THERAPY PROCEDURES
Balance	Balance board, Walking Rail, Primitive Reflexes, Balance Tracking System Training, Trampoline, Swing,
Visual Perception	Parquetry Blocks, Form Boards, PTS II Software, Vivid Software, Vision Builder, Multi-Matrix, Geoboard, Rush Hour, Set Games
Reading Ability	Hart Chart Saccades, Sequential Letter Tracking, Phonetic, Saccadic sticks, Life Saver Cards, Barrel Cards, Lenses, Prisms, Bull's eye Target, Antisuppression Charts, Groffman Charts, Aperture Rule
Peripheral V-M Coordination	Fit Light, Bean Bag Toss, Sanet Vision Integrator, Strobe Lights, Macdonald Charts, Tachistoscope, Rotation Trainer, Press Lites

These procedures are detailed in:
Applied Concepts in Vision Therapy 2.0. LJ Press, MB Taub, PH Schnell, eds. Timonium MD: Optometric Extension Program Foundation, 2022. Chapters 20, 24, 25. 26, and 27.